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Articles

An Opportunity Cost View of Fixed Asset Theory and the Overproduction Trap

Marc A. Johnson and E. C. Pasour, Jr.

In fixed asset and exit barrier theories, durable asset valuation is based upon acquisition prices, yielding downwardly biased rate-of-return estimates and erroneous implications that excess resources become trapped in production when product price expectations fall. Conventional asset valuation based on opportunity cost shows that excess resource applications are incompatible with rational producer behavior. Market failure conclusions of overproduction trap models are shown to be unfounded. A review of recently published agricultural economics texts illustrates how use of fixed asset theory in the college classroom obscures the concept of choice-influencing cost and the rule of resource allocative efficiency.

Key words: entrepreneurial choice, fixed asset theory, opportunity cost, rate of return.

Two similar theories of the firm attribute "persistently low rates of return" to invested capital to an inability of the firms to remove "excess resources" from production. Fixed asset theory, developed by Johnson and his colleagues (Johnson 1958, 1960; Johnson and Hardin; Johnson and Quance; Johnson et al.), formalized by Edwards, and popularized by Hathaway, suggests that fixed resources were "trapped" in agriculture resulting in persistently low returns to resources applied in agriculture during the quarter century following World War II. Caves and Porter present a theory of exit barriers arising from applications of "inputs that can become attached to the firm and then command persistently low earnings because they are *durable* and *specific* to an activity of the company" (p. 40).

Fixed asset and exit barrier theories suggest that overcommitment of durable resources, indicated by persistently low rates of return, is an inherent feature of business activity. The purposes of this paper are to (*a*) review the conventional theory of resource adjustment to show that excess durable resources are incompatible with rational producer behavior when resource costs are measured conventionally as opportunity costs, (*b*) demonstrate that fixed asset and exit barrier theories yield downwardly biased rate-of-return estimates having erroneous implications for resource adjustment, (*c*) demonstrate the inappropriateness of using fixed asset theory to judge entrepreneurial efficiency, and (*d*) illustrate the extent to which fixed asset theory is used in current agricultural economics texts.

Resource Adjustment Theory

Conventional economic theory states that a profit-maximizing firm, satisfying second-order conditions and selling in a competitive product market, will apply a quantity of each resource i in the production of product j in period t just to equate the value of marginal product (VMP_{ijt}) and the marginal factor cost (MFC_{ijt}), i.e.,[1]

$$(1) \qquad VMP_{ijt} = MFC_{ijt}.$$

Use of a unit of a durable resource entails application of the unit for a period of time to contribute to the production of value. Anticipated marginal product generated by a durable item, as for nondurable items, is the anticipated, incremental output attributable to pro-

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[1] The conventional analysis assumes a single-period production cycle or, alternatively, that production and cost conditions facing the firm are the same in each period of the production cycle. Moreover, if the firm attempts to maximize wealth over time, single-period flows do not provide sufficient information to determine output choices for that period (DeAlessi).

duction with the item rather than without; this output multiplied by expected product price is the expected value of marginal product of the durable item.

Economic resource cost is conventionally defined as opportunity cost, the value of a resource in the best alternative use.[2] For resource units not owned by the firm, opportunity costs are measured as prices for nondurable items and as operating costs (C_{ij}) plus either rental rates or overhead costs for durable items. Overhead costs include depreciation (anticipated change in the value of the asset during the production period ΔV_{ijt}) and interest cost, rV_{it}, where r is the opportunity cost of capital per period and V_{it} is the value of the stock at the beginning of production period t. For a non-owned resource unit, V_{it} would be evaluated at acquisition price during the first production period. For resource units owned by the firm, opportunity cost of using a durable unit for a period is measured as operating cost plus an overhead cost based on either a salvage market comparison ($\Delta V_{ijt} + rV_{it}$, where V_{it} is evaluated at current salvage price) or an internal use comparison (the unit's value in production of another product within the firm less resource switching costs), whichever is higher.[3] Thus,

$$(2) \qquad MFC_{ijt} = C_{ijt} - \Delta V_{ijt} + rV_{it}.$$

Each unit of resource, owned or not owned, has a single-valued, expected opportunity cost at the moment of decision making, depending upon its position with respect to space, time, condition, and ownership. Costs of using different units may differ by transport, storage, conditioning, and transaction costs, respectively.

Substituting the definition of MFC_{ijt} in equation (2) into the resource adjustment rule of statement (1) shows that additional units of resource i will be applied to enterprise j in time t until[4]

$$(3) \qquad VMP_{ijt} = C_{ijt} + \Delta V_{ijt} + rV_{it}.$$

Subtracting noninterest cost components from each side and dividing by V_{it} reveals the rate of return on the investment of applying the marginal resource unit to enterprise j in time t,

$$(4) \qquad \frac{1}{V_{it}} (VMP_{ijt} - C_{ijt} - \Delta V_{ijt}) = r.$$

Application of a capital item to an enterprise must yield a rate of return equivalent to the opportunity cost of capital, r. Stated differently, a rational producer would not use input i to produce product j if its expected return were greater in another use. Consequently, rational producer behavior results in expected marginal economic rates of return to durable resources at least equivalent to the producer's opportunity rate of return.

Measurement of asset value, V_{it}, is critical to the conclusions of fixed asset and exit barrier theories, viz., that resources become trapped in production and yield rates of return less than the opportunity cost of capital. When deciding to adjust levels of resource use, each unit of resource will carry its own cost of use according to the active opportunity foregone for the unit in its existing position with respect to space, time, condition, and ownership. If an additional unit must be purchased from the market, V_{it} is evaluated at acquisition price. If an additional unit is drawn from a currently owned stock, V_{it} is evaluated either as net present value of the unit applied to another internal enterprise or as the market salvage value. When market acquisition price for a new unit exceeds market salvage price of an owned unit, it is quite possible for the expected rate of return to a marginal, owned unit to equal or exceed the opportunity cost of capital while the expected rate of return to a marginal, new unit falls below opportunity cost of capital. In this situation an owned unit would be attracted to enterprise j while a new unit would not.

Excess Durable Resources

The following sections present two theories which contend that durable resources are economically bound in production, resulting in excess resource applications and low returns on investment. In the next section, fixed asset theory is summarized briefly and its implication of overproduction and persistently low rates of return on investment is shown to be erroneous due to inappropriate measurement of resource cost.

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[2] Opportunity costs are based on anticipations. Consequently, cost is necessarily a forward-looking *ex ante* concept (Buchanan 1969).

[3] Internal use of resource i in another enterprise, k, would affect the value of the resource V_{it}. The internal use value of the marginal resource unit applied to enterprise k is

$$V_{it} = \Sigma_t (VMP_{ikt} - C_{ikt})(1 + r)^{-t}.$$

[4] An inequality, $VMP_{ijt} \geq MFC_{ijt}$, could result in the event of a discontinuity in the MFC_{ijt} function, e.g., the firm having applied the last internally owned unit is required to enter the market for additional units which are positioned differently.

Fixed Asset Theory

The theory of asset fixity is distinguished from conventional production theory by focusing on a divergence between acquisition and salvage prices of "identical" units of durable resources. The fixed asset for the single variable input case is illustrated in figure 1. (Implications are similar for the multiple input case.) When product price is high (as indicated by VMP_1), the firm finds it profitable to obtain Oa units of X_1. According to the theory, if product price should fall later so that VMP_2 is relevant, X_1 becomes a fixed asset because VMP at quantity Oa lies between acquisition and salvage prices. The within-firm opportunity cost of the input (shown in fig. 1) is assumed to exceed the market opportunity cost, or salvage value. However, a fixed asset is defined to be one for which the acquisition value exceeds the VMP and the VMP exceeds the salvage value (Johnson et al.).

A firm with one or more fixed assets implies "overcommitment" of resources in the sense that the VMP for each of the fixed assets is less than its acquisition price. Because the VMP of the resource lies between respective acquisition and salvage prices, quantities of resources applied are fixed and no adjustment would be initiated. Producers continue to use amounts of inputs purchased earlier when higher product prices were anticipated. Thus, the conclusion of fixed asset theory is that there is an "overproduction trap."

The conclusion of fixed asset theory that excess resources are "trapped" in production can be traced directly to selection of acquisition prices of resources as a benchmark for equilibrium production. But, there is no reason to expect the opportunity cost of a resource once acquired to equal its historical acquisition price. The choice-influencing cost associated with the use of any resource is the value of the foregone opportunities. For a single-product firm, the opportunity cost of using a unit of an owned durable resource is the market salvage value. For a multiple-product firm, the opportunity cost of an owned resource is the value in the best alternative use, including external sale. Thus, historical costs cannot legitimately be considered opportunity costs.[5]

When owned assets are valued on the basis of opportunity cost, fixed asset theory no longer implies that resources are "trapped" in agriculture (i.e., that the VMP is less than cost for any asset in use). The VMP may be less than historical cost but, as stressed above, "past costs are lost costs" and are irrelevant for current decisions. The concept of trapped or excess resources is thus inconsistent with rational behavior because the entrepreneur would never knowingly use a resource where the expected VMP is less than the expected opportunity cost.[6]

If overproduction and excess resource applications are inconsistent with rational behavior, what is the basis for the alleged low returns to durable capital resources? The preceding analysis suggests that the fixed asset theory conclusion, that the VMP of a fixed resource is below resource costs yielding a persistently low return, is inherent in the inappropriate measurement of resource cost.[7] A difference between acquisition and salvage price, as shown by recent work in information and search theory, is to be expected for all resources and can be directly attributed to resource positioning and transactions costs (Akerlof, Stigler). For example, the fact that the market value of a tractor or combine a few

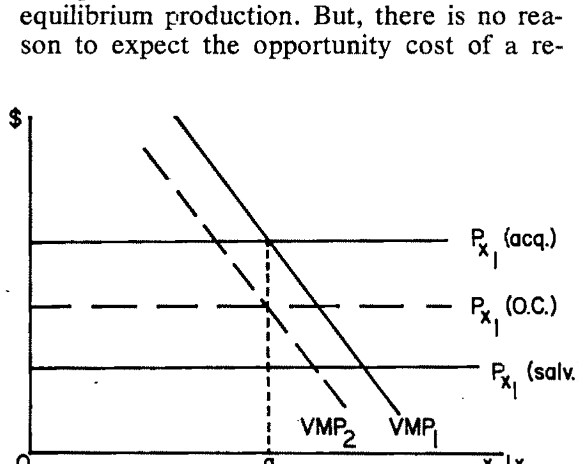

Figure 1. The single-input fixed asset case

[5] "There is no reason for supposing that the price one has paid for materials, or a figure derived from a calculation based on the prices one has paid, will give one the 'opportunity' cost of using materials. . . . On the one hand it ignores the expenses involved in reselling materials one has purchased—expenses which may be quite considerable; on the other hand it does not take into account the value of the materials if used for some other job" (Coase, p. 113).

[6] Where means and ends are assumed given to the decision maker, there is no scope for the entrepreneurial element. In a world of imperfect knowledge and costly information, where the entrepreneur is given information on neither ends nor means, estimating costs and benefits associated with alternative production strategies is a key entrepreneurial function (Kirzner).

[7] When opportunity cost is taken as the magnitude affecting entrepreneurial choice, it becomes clear that the decision maker would never knowingly sell a product below cost or use resources valued below cost, i.e., below the value of opportunities foregone.

days after purchase is substantially less than the price paid can be explained in terms of uncertainty and information costs. The fact that the current value is substantially below the acquisition price does not imply an overcommitment of resources. Furthermore, acquisition price in fixed asset theory is often measured as a historical purchase price, whereas salvage price arises from evaluation of salvage opportunities at a point later in time (Johnson 1958, pp. 77–78; 1960, p. 41). Consequently, the resulting measure of costs in fixed asset theory is upwardly biased relative to opportunity costs, yielding downwardly biased rates of return on invested capital relative to actual returns computed on the basis of opportunity costs.

Asset fixity theory also is used to make *ex post* evaluations of entrepreneurial decisions: "When a product price falls below prices anticipated at the time durable investments are made, an error of overproduction occurs" (Johnson and Quance, pp. 27–28). Here fixed asset theory as a resource-adjustment decision rule attempts to use accounting records (the objective historical record) to evaluate the astuteness of entrepreneurial decisions. However, entrepreneurial choice is concerned with expected costs and returns of future production, and the outside observer cannot obtain the data relevant to choice. Consequently, there may be little or no relationship between objectively defined costs and benefits and the evaluations that individuals place on alternatives in actual choice situations (Buchanan 1969b). Furthermore, it is not legitimate to use *ex post* data to evaluate entrepreneurial efficiency. To conclude that farmers are inefficient because they are not omniscient and make mistakes is to say little more than that the competitive equilibrium would be different if these were not facts of life (Demsetz). Entrepreneurial activity that is shrouded in uncertainty will always appear inefficient if judged against the perfect competition norm of static equilibrium theory, which implicitly assumes that there are no information and uncertainty problems. Thus, the entrepreneurial function is inherently subjective and the economist has no objective procedure (except for the survivor principle) to measure the efficiency of entrepreneurial activity.[8]

Although one cannot legitimately use derived equilibrium conditions as a norm against which to judge efficiency, the marginal principles of production theory are useful to the decision maker as a logic of choice. These principles can help the entrepreneur think in marginal terms and their use may produce "better" choices as evaluated by the decision maker's own standards (Buchanan 1969b).

Exit Barrier Theory

The exit barrier theory of Caves and Porter is similar to fixed asset theory developed by Johnson twenty years earlier. Emphasis is placed on the "limited salvage value" of durable specific assets. Caves and Porter purport to show that excess resources are "an element of market structure and *ex ante* determinant of market conduct and (thereby) performance" (p. 39). Exit barriers are alleged to result in persistently "subnormal" profits. Exit barriers arise because resources are "durably committed . . . to an activity of the company" (p. 40). Resources become durable because, once purchased, their value in use exceeds their salvage value. Durable assets include not only traditional, long-lived, specialized equipment but also working capital and intangible assets. Partly fabricated goods have a low salvage value relative to their value in finished form. Intangibles, such as trademarks, have a low salvage value because of limited markets. Labor with specific skills has a greater value in present use than in other uses not requiring the skill. All of these resources are considered durable in the sense that they are specialized to a particular firm and their value to the firm exceeds the salvage value. Durability, then, refers to a difference in value associated with the positioning of the resource rather than to an inherent physical characteristic; thus, a durable asset to Caves and Porter is a fixed asset to Johnson.

Rates of return on durable resources in the exit barrier theory are based on accounting data. Cost is taken to be the original (historical) purchase price less depreciation. The perceived exit barrier problem is one of low rates of return to durable assets. But rates of return, as in fixed asset theory, are measured in an *ex post* fashion by comparing value of marginal product with original purchase price. Cost as it

[8] As Coase suggests, "the correctness of the decision cannot be determined by subsequent events. If a businessman undertakes to do something which entails certain risks, he considers the choice of gain is worth the risk he runs, and whether ultimately he succeeds or fails has no relevance to this preference" (pp. 104–5).

motivates entrepreneurial choice, however, always deals with current alternatives. Historical cost provides no opportunities for choice. A correct measure of rate of return on resources used in any production process is to compare value of marginal product with current opportunity cost. The fact that the resource is "durable" to the firm suggests a marginal rate of return greater than the market interest rate. If the resource has a higher expected value in a competing use, the resource would not remain in its present use. The limited salvage value of durable assets, then, does not imply that inputs remain in use because of exit barriers; instead, the resources remain in use because the rate of return in the present use represents the most profitable alternative for these resources. Again, with appropriate opportunity cost measurement of resource cost, excess resources are incompatible with rational producer behavior.

"Excess Resources" in the Classroom

Excess resource arguments as a "convincing" foundation for low returns to capital in agriculture are prevalent in agricultural economics texts. The Caves-Porter exit barrier theory is quite recent, and its eventual impact on firm theory is uncertain. However, fixed asset theory has had an important influence in applied agricultural production and policy economics. The result is that students are presented unclear concepts of cost, investment evaluation, and entrepreneurial choice criteria. A review of several recently published agricultural economics texts reveals that, in at least three introductory agricultural economics texts and three agricultural policy texts, the notions of asset fixity are used to explain low returns to capital and labor resources applied to agriculture.

Fixed asset theory is used in the Goodwin and Halcrow (1980) introductory texts to explain low returns to durable resources as a problem of resource adjustment for the farm firm. On pages 312 and 318 of the Goodwin text, the difference between acquisition and salvage prices is evaluated following a lapse of time, and contraction of activity is described as "tortuous and painful because he cannot salvage these fixed assets at their full value." Halcrow implies that the choice of prices to use in investment evaluation and profit measurement is arbitrary:

> The net return from the use of a tractor may be below a normal rate of return based on the acquisition price, P_A, but well above the liquidation price, P_o. Many farmers who bought tractors and equipment in 1973–1975, for example, when grain prices were high, were able to justify their purchases on the basis of those prices. But in the late 1970s when grain prices were lower, those farmers were unable to make a normal profit, based on P_A, although the price of grain was well above their close-down level. (Halcrow 1980, pp. 214–15)

These conclusions need not bear normative sadness if resource allocation and cost measurement rules are based on opportunity costs. The fact that resources become "fixed" may be interpreted to mean that resources continue to be allocated in the activity yielding their highest return. Resources are moved when there are greater opportunities elsewhere. The fact that resources might have been better placed originally is irrelevant from the standpoint of current allocative efficiency. Stated differently, sunk costs are irrelevant to current decisions. Furthermore, mistakes are inevitable when operating under real world conditions of risk and uncertainty.

The Doll-Rhodes-West general agricultural economics text filters out the best of what asset fixity theory has to offer. The theory is used only for questions of farm resource adjustment at a moment in time. Acquisition and salvage prices are evaluated simultaneously and, at any moment, a decision maker chooses among three options: to expand, to contract, or to continue unchanged.

Fixed asset theory is used in policy discussions to explain low levels of agricultural prices and irreversible aggregate, agricultural supply functions. The policy chapter of the Wilcox-Cochrane-Herdt text suggests that resource fixity results from the fact that "land and sunk capital cannot be moved" (p. 296). The authors imply that this is a reason for low agricultural prices, without stating that rates of return in agriculture, based on current asset values, still may be competitive with returns on assets of comparable risk.

The Halcrow (1977) agricultural policy text uses asset fixity to explain farm labor immobility and subsequent supply inelasticity in agriculture. Agricultural labor is alleged to be fixed in agriculture because these individuals do not have opportunities valued as highly as the acquisition price necessary to attract new workers to agriculture. The logic is not complete for judging the opportunities of one

group against the opportunities of another. Doll, Rhodes, and West correctly define labor resource fixity as a situation where returns to labor in the current activity exceed opportunity returns, with no mention of an irrelevant acquisition labor price.

Tweeten's agricultural policy text presents asset fixity as one of three theories to explain "why . . . resources (don't) move out of agriculture at a rate sufficient to bring equilibrium returns" (p. 178). Tweeten discounts the importance of asset fixity to the farm problem not by rejecting the theory but by showing that each resource group involved in agriculture is not very durable or has salvage prices only slightly below acquisition prices. The irrelevance of acquisition prices in computing the rate of return to agricultural resources in place is not discussed.

The O'Rourke policy text presents Johnson-Hathaway asset fixity theory as an explanation of slow adjustment in agriculture to lower prices. However, as suggested above, the seemingly slow adjustment to price decreases is more likely a reflection of competitive returns to resources valued on the basis of opportunity costs rather than an indication of low returns as suggested by asset fixity theory.

Use of fixed asset theory in agricultural policy discussions can be summarized as implying that the supply function is not reversible and independent of the direction and duration of changes in product prices (Plaxico; Vincent, chap. 7). However, supply analysis based on the Marshallian distinction between "fixed" and "variable" factors yields a similar result, viz., supply curves are more elastic the longer the length of run and the supply function is not reversible (Becker, pp. 79–83). This relation between duration and cost occurs even in the absence of uncertainty about the time period of demand changes. Thus, the supply response conclusions drawn from the fixed asset model are not unique.[9]

Conclusion and Implications

The theories of asset fixity and exit barriers both have been formulated to address the alleged problem of persistently low rates of return to invested capital. In estimating rates of return, both approaches use (historical) acquisition costs rather than opportunity costs applicable at the time when rates of return are estimated. Both approaches focus on resource allocation where resource values in use have fallen below acquisition prices, but not below salvage values, and conclude that these resources are trapped in their current use while yielding a low rate of return. However, the relevant rate of return for any asset should be based on the value which motivates entrepreneurial choice, the current opportunity cost. When rates of return are evaluated on the basis of current opportunity costs, the implications are quite different—resources are shown to be rationally attracted (retained) in their current use rather than being trapped there, and rates of return are competitive with current alternatives.

A difference between acquisition and salvage prices of assets, as shown by the Caves-Porter exit barrier theory, is not unique to the agricultural sector. In the real world markets, information is scarce and costly and salvage values for assets once acquired are generally lower than acquisition costs. Fixed asset theory can be useful in stressing the role and importance of information and transactions costs in explaining differences between costs of inputs positioned differently in time or space. Moreover, the theory can contribute toward an understanding of why the supply function, whether firm or industry, is not reversible and is more elastic the longer the length of run. However, the appropriate focus of fixed asset theory is on the reasons for the divergence between acquisition and salvage prices rather than on resources being "trapped in use.' The implication of market failure, in the sense that resources are misallocated, is not warranted in either theory of excess durable resources.

A difference between acquisition and salvage values does not imply that current asset markets are inefficient. While acquisition and salvage values are equal in a "perfect market," it is inappropriate to measure the efficiency of resource markets against the perfect market norm which assumes that decision makers have perfect knowledge and that positioning costs are zero. When measured against the perfect market norm, all markets will appear to be "inefficient" (Demsetz). If a difference between acquisition and salvage value is

[9] "While the conceptual model is useful in categorizing inputs, the conclusions drawn from the model are no different from those reached by other agricultural economists. Namely, the lack of profitable alternative uses for certain inputs such as family labor limits the response of supply to a fall in farm prices, at least in the short run. and especially in periods of general depression" (Tomek and Robinson, p. 360, 61).

taken to imply resource fixity, then virtually all real world markets are characterized by asset fixity. Theories of excess durable resources based on a difference between acquisition and salvage values hinder students from acquiring a precise concept of choice-influencing cost and of the rule for resource allocative efficiency under real world conditions where information and resource positioning are costly.

The entrepreneurial function concerned with exploiting profit opportunities has not been handled adequately by excess resource models or by maximization models generally in economics. If one assumes that the decision maker has perfect knowledge, then there is no scope for entrepreneurial activity. Moreover, if it is recognized that the entrepreneur operates in an atmosphere of risk and uncertainty, it is inappropriate to measure performance against a model which assumes away these problems. Entrepreneurs inevitably will make mistakes from the viewpoint of hindsight or an omniscient observer when dealing with the uncertain future.

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Price Distortions in Agriculture and Their Effects: An International Comparison

Malcolm D. Bale and Ernst Lutz

The central thesis of this paper is that agricultural pricing policies pursued by developing countries produce effects which are diametrically opposite to those produced by the pricing policies of many developed countries, and that the policies of both are costly in terms of global welfare. In general, the agricultural sector in developing countries is heavily taxed while that in the developed countries receives substantial price protection. The effects of agricultural price distortions on output, consumption, trade, and rural employment are estimated for nine countries. In addition, the effects of price distortions on the distribution of income between producers and consumers, on government revenue and foreign exchange, and the net social losses of the policies are calculated.

Key words: agricultural policies, price distortions, social costs, trade intervention, welfare analysis.

While in some parts of the world agricultural policy must deal with the problem of surpluses, in other parts of the world—particularly in developing countries—agricultural output is often insufficient to cover basic food needs. The reasons are many and varied, ranging from distribution and production techniques to political intervention at various levels in the global agricultural complex. While the most important reasons for inadequate agricultural output are difficult to ascertain, T. W. Schultz, in the first Elmhurst Memorial Lecture to the International Association of Agricultural Economists, left no doubt as to his ranking of the causes. He stated that the level of agricultural production depends not so much on technical considerations, but in large measure "on what governments do to agriculture." (See also Schultz 1977, 1978.)

It is well known that governments intervene in the agricultural price-setting mechanism in many different ways and for assorted reasons. For example, export taxes on agricultural products provide government revenue and help keep domestic prices low; product price supports in developed countries maintain farm incomes and lead to surpluses which in turn find their way to developing country markets often on concessional terms, further depressing domestic farm prices; and agricultural inputs are frequently either taxed or subsidized. Yet, the magnitude of the effects of these policies on agricultural output, income distribution between producers and consumers, efficiency, and on rural employment is often not fully appreciated.

The ways in which governments can intervene to alter market incentives in agriculture can be classified in three ways, based on their impact on output (after Schultz 1978). First, there are economic policies that are neutral with respect to the opportunity cost of agricultural production. Second, there are those where agricultural production is overvalued. And, finally, there are policies through which agricultural production is undervalued. Only a few countries meet the first classification (they are not identified here). Typically, high-income developed countries fall into the second category. In this study, we examine Japan, West Germany, France, and Great Britain, countries where levies are placed on grain imports, where imports of sugar, meat, and dairy products are restricted by quotas, and where, in the case of Japan, rice is greatly overpriced relative to world levels. The immediate consequences of these policies are overproduction and underconsumption of ag-

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The views and interpretations in this paper are those of the authors and should not be attributed to the World Bank, to its affiliated organizations, nor to any individual acting in their behalf.

ricultural output. The third category typically is made up of low income developing nations. Here, as examples, we examine the pricing policies of Thailand, Egypt, Argentina, and Pakistan, where export taxes and price controls often undervalue agricultural output, resulting in underproduction. Many of these nations produce insufficient foodstuffs, and they cannot afford to forego production opportunities. In addition, we consider the case of Yugoslavia, classified both as a developing country and as a centrally planned economy.

This paper discusses government intervention in the determination of agricultural product prices, drawing on welfare theory to quantify the economic impacts on output, income distribution, efficiency, and employment. The general theme is that the agricultural policies pursued by developing countries produce effects which are diametrically opposite to those of many developed countries, and that the policies of both are costly in terms of global welfare. (A recent study which addresses the developing country side of this question in a somewhat different manner is Peterson.) The paper begins with a description of the theoretical model on which the analysis is based and then continues by detailing the data sources; results are presented in the next section, followed by some concluding thoughts.

Method and Theoretical Basis

The results of the paper are derived using standard partial equilibrium comparative static analysis in the Marshallian economic surplus framework. The method is well known for both its usefulness and limitations. Details on this approach are not presented here, but the reader is referred to Currie, Martin, and Schmitz for an excellent review of the concept, to Bale and Greenshields for an application, and to Lutz and Scandizzo for a review of other studies.[1] In this paper, the real and pecuniary effects of agricultural price distortions are analyzed using nominal protection coefficients (NPCs) to measure the disparity between domestic output prices and border prices. Typical causes of price distortions evaluated here are producer price supports, tariffs, quotas, export taxes, and overvalued exchange rates. Input subsidies for irrigation water, fertilizer, and credit are not considered because of the difficulty of obtaining cross-country data and because of the impossibility, in the case of water, of evaluating a "market" rate when its costs and lifetime are unknown. In each case, the intervention drives a wedge between the domestic price and the world or "border" price. Domestic prices are defined as the prices at farm and consumer levels, converted into U.S. dollars, using shadow exchange rates; border prices are the existing "world" prices at the same point in the marketing chain (i.e., the small country assumption has been used). Border prices are used as the point of reference for the evaluation because they represent the opportunity cost of the traded commodities.[2] They are also conveniently available as they are observed in the international marketplace. Nominal protection coefficients provide a measure of the disparity between domestic prices and international prices, and are defined as

$$NPC = 1 + \frac{P_d - rP_w}{rP_w} = \frac{P_d}{rP_w},$$

where P_d is domestic price, P_w is border price, and r is the equilibrium exchange rate.

The basic analytic structure of the model is represented by equations (1) through (7):

(1) net social loss in production

$$NSL_p = 1/2\,(Q_w - Q)\,(P_w - P_p) = 1/2\, t_p^2\, n_s\, V,$$

[1] While the method is widely used, it is not without its detractors. There is, in fact, a considerable body of literature and an ongoing theoretical debate regarding the appropriateness of using the underlying utility functions in evaluating welfare gains and losses across individuals or countries. The debate centers on whether consumers' surplus analysis provides a measure of benefits and losses in terms of the "compensating variation" and the "equivalent variation" in the contemporary Hicksian form. Bergson clarifies this debate, finally noting that "despite theoretical criticism, practitioners have continued to apply surplus analysis through the years . . . that must say something about the usefulness of such analysis" (p. 43). Willig, in a later article whose "purpose is to settle the controversy surrounding consumers' surplus and, by so doing, to validate its use as a tool of welfare economics," demonstrates theoretically that "consumers surplus is usually a very good approximation to the appropriate welfare measures" (p. 589).

[2] We recognize that the general equilibrium effects of removing price distortions on a global basis would alter border prices and therefore alter the magnitude of the distorting effects. However, it is extremely difficult to estimate "shadow-free market prices" in a first-best world, and we do not suppose that we will ever be operating in a first- or even second-best environment.

In our analysis there are some cases where the use of the small country assumption may have introduced a bias into our results. Both for exporting countries and for importing countries our method may overestimate the true effects. This may apply to rice in Thailand, cotton in Egypt, wheat in Japan and wheat in France. When some large countries are being considered simultaneously, the effects can be additive or they can cancel each other out. For example, while the export taxes of some developing countries may increase the world market price the import tariffs of some industrialized countries may depress it.

(2) net social loss in consumption

$$NSL_c = 1/2\ (C_w - C)\ (P_c - P_w) = 1/2\ t_c^2\ n_d\ W,$$

(3) welfare gain of producers

$$G_p = Q\ (P_p - P_w) - NSL_p,$$

(4) welfare gain of consumers

$$G_c = C\ (P_w - P_c) - NSL_c.$$

(5) change in foreign exchange earnings

$$dF = -P_w\ (Q_w - Q + C - C_w),$$

(6) change in government revenue

$$dG = (NSL_p + NSL_c) - G_p - G_c = -(1) - (2) - (3) - (4), \text{ and}$$

(7) change in rural employment

$$dL = dQ\ L/Q,$$

where Q_w is production at world prices; Q, production at domestic prices; P_w, border prices; P_p, price faced by domestic producers; P_c, price faced by domestic consumers; t_c and t_p, proportion of tariff in domestic price at the consumer (t_c) or the producer (t_p) level; n_s, elasticity of domestic supply; n_d, elasticity of domestic demand; V, value of production at P_p; W, value of consumption at P_c; C_w, consumption at world prices; C, consumption at domestic prices; and L/Q, labor/output coefficient.

Because border prices are used as the basis for comparison, the domestic prices used must correspond to the same point in the marketing chain. In calculating NPCs, farmgate prices in developing countries have been adjusted upward to take into account different transportation costs and marketing margins to the central market. (For specific details, see country case studies referenced.) The prices used may therefore be described as wholesale prices. For industrial countries, wholesale prices as reported were used in the study.

In measuring the cost of protection, the use of equivalent tariff levels—which are necessary for agricultural products facing many nontariff barriers—means that production and consumption effects are measured at the wholesale level rather than at the farm and retail levels. This may result in the underestimation of the welfare costs. For example, consider the following demand function:

$$Q = \alpha - \beta P_r, \text{ where} \tag{8}$$

$$P_r = P + f(P), \text{ and} \tag{9}$$

$$dP_r = dP\,[1 + f'(P)], \tag{10}$$

where P_r is retail price, P is wholesale price, and $f(P)$ is marketing margin. The measured change in consumers' welfare is

$$dP\ (C - 1/2dQ), \tag{11}$$

where C is consumption at domestic prices. The actual change in consumers' welfare is

$$dP_r\ (C - 1/2dQ). \tag{12}$$

From equation (10), if $f'(P) = 0$, that is, if the marketing margin is constant, then the welfare estimate is unaffected by the choice of price. If $f'(P) > 0$, implying that markups increase as price increases, then the welfare effect is understated. The same exercise may be performed on the producer's side with the same results. Thus, where it can be assumed that marketing margins are constant, no bias occurs. At a practical level, the use of a wholesale price can be justified on several grounds. Many products undergo transformation into different products between the wholesale and retail level. Thus, a single retail price does not exist for the product. This may be true for wheat, barley, maize, and beef in many countries. In some developing countries, where grains are used in households, wheat is subsidized such that wholesale and retail prices are similar. Given these factors, we have been forced to compromise the ideal and to use what is available.

Data Sources

The base year of the analysis is calendar 1976. The *FAO Production Yearbook* was used as a source for production levels; imports and exports were obtained from the *FAO Trade Yearbook*. Given the unavailability of data for consumption and stocks, particularly for developing countries, consumption was derived from production and trade data, assuming the levels of stocks remained unchanged. Supply and demand elasticities were taken from Rojko et al. In all cases they are long-run, general equilibrium elasticities, although here we suppress the cross-price terms.[3] Because elasticity estimates differ widely from re-

[3] The cross-price terms are small and cannot be used in standard welfare analysis. We use the Rojko elasticity measurements because they provide a consistent set of elasticities for the commodities and countries used here. Since elasticity estimates can differ we have used range analysis.

searcher to researcher, and because we wished to demonstrate the sensitivity of the results to changes in elasticities, the supply and demand elasticities presented in table 1 are ±0.5 times the point estimates given by Rojko et al.

Nominal protection coefficients for developing countries were derived from detailed country case studies by Bertrand (Thailand), Cuddihy (Egypt), Gotsch and Brown (Pakistan), Reca (Argentina) and ULG Consultants (Yugoslavia). In order to make adjustments for currency overvaluation, the nominal protection coefficients were multiplied by the following ratios between the shadow exchange rate and the official exchange rate of the different countries as estimated by the World Bank: Argentina, 0.8; Egypt, 0.69; Kenya, 0.76; Pakistan, 0.91; Portugal, 0.83; Thailand, 0.88; and Yugoslavia, 0.98. Shadow exchange rates for developed countries are not estimated and are here assumed to be the same as market rates.

The nominal protection coefficients for developed countries were calculated from data of the International Wheat Council, International Sugar Organization, U.S. Department of Agriculture (1979), and the World Bank. Note that despite the Common Agricultural Policy of the European Economic Community (EC), NPCs of members are not identical. This is due to the "Monetary Compensatory Amounts" (MCAs) and "green" currencies, because of which internal EC exchange rates in agriculture differ from official exchange rates.

Labor/Output Coefficients were constructed from Bartsch, Palacpac, International Cotton Advisory Committee, U.S. Department of Agriculture (1978a, b), United Kingdom Ministry of Agriculture, Forestry, and Fisheries, and the European Communities Commission. In the case of developing countries, marginal labor/output coefficients were derived from a labor-intensive technology, such as hand harvesting with a bullock-drawn cart and hand threshing. Average coefficients are simply the average of coefficients taken from two or three different production techniques on irrigated and nonirrigated farms. In developed countries, only average coefficients were available. Marginal coefficients in these countries were assumed to be 1.5 times the average coefficients.[4] The conversion rates of man-hours to full-time worker equivalents, in hours per year, are: France, 1,964; Germany, 2,315; United Kingdom, 2,269; Japan, 2,450; Yugoslavia, 2,450; and developing countries, 2,980. The basic data used in our analysis is shown in table 1.

Our use of a rather simplistic model of rural employment, and its change relative to output, is based on an input-output view of agricultural production. This approach was used by Thorbecke, where the following equation was estimated:

$$E_A = \alpha_0 + \alpha_1 Q_A,$$

where E_A is employment in agriculture and Q_A is agricultural output. Such an approach obviously produces a constant labor-output coefficient, a shortcoming of any linear system, which in turn implies a constant marginal physical product of labor. While more sophisticated models have been developed and estimated by others (for example, Todaro), we have assumed constant input-output coefficients.

Results

We first consider the merchandise effects.

Production, Consumption, and Trade Effects

Agricultural pricing policies in developed and developing countries are significantly different. While prices for agricultural commodities in developed countries generally have positive rates of protection, in developing countries commodities are often taxed through price intervention measures. As a result, the levels of agricultural production in industrialized nations are higher than they would be without intervention, whereas agricultural output in less developed countries is significantly smaller than what it would be in the absence of distortions. In the high elasticity case, France and Germany, for example, are producing an increment of 4.3 and 2.8 million tons of wheat, respectively, because of price protection, whereas in Argentina and Pakistan, production is discouraged, with a resulting estimated decrease of 7.0 and 1.3 million tons, respectively (table 2).

[4] The assumption that marginal coefficients are 1.5 times the average coefficient for developed countries is broadly consistent with the Hayami and Ruttan estimate of 2.5 for a sample of developing and developed countries. Clearly the inclusion of highly labor intensive techniques in developing countries makes the Hayami and Ruttan estimate higher than ours.

Table 1. Basic Data Used for the Analysis, 1976

Country Commodity	Border Price US$/mt	NPC[a]	Range of Supply Elasticities		Range of Demand Elasticities		Produc-tion	Consump-tion	Exports	Labor Coefficients	
			Low	High	Low	High				Average	Marginal
							------('000 metric tons)------			(Man-hours per ton)	
France											
Wheat	143	1.26	.42	1.28	−.10	−.30	16,150	7,785	8,365	25	37.5
Maize	152	1.31	.17	.52	−.20	−.60	5,603	4,486	1,117	37	55.5
Barley	137	1.39	.42	1.28	−.10	−.30	8,530	5,637	2,893	25	37.5
Sugar	289	1.35	.81	2.44	−.12	−.36	2,974	1,957	1,017	52	78.0
Beef	2,365	1.27	.20	.60	−.35	−1.05	1,821	1,706	115	40	60.0
Germany											
Wheat	143	1.49	.42	1.28	−.10	−.30	6,702	7,252	−550	25	37.5
Maize	150	1.57	.17	.53	−.20	−.60	480	3,776	−3,296	37	55.5
Barley	137	1.51	.42	1.28	−.10	−.30	6,487	7,973	−1,486	25	37.5
Sugar	289	1.77	.43	1.30	−.08	−.24	2,733	2,584	149	52	78.0
Beef	1,970	1.42	.20	.60	−.35	−1.05	1,365	1,435	−70	40	60.0
United Kingdom											
Wheat	156	1.15	.47	1.42	−.10	−.30	4,740	8,419	−3,679	25	37.5
Maize	131	1.28	.45	1.35	−.20	−.60	2	3,720	−3,718	37	55.5
Barley	132	1.01	.47	1.42	−.10	−.30	7,648	8,096	−448	25	37.5
Sugar	283	1.39	.22	.66	−.10	−.30	746	2,558	−1,812	52	78.0
Beef	1,542	1.17	.20	.60	−.35	−1.05	1,064	1,177	−113	40	60.0
Japan											
Wheat[b]	189	2.81	.80	2.41	−.08	.24	222	6,043	−5,821	54	81.0
Barley[b]	160	3.14	.80	2.41	−.08	−.24	210	1,971	−1,761	54	81.0
Sugar	306	1.36	.21	.64	−.11	−.33	560	2,986	−2,426	110	165.0
Beef	2,252	1.30	.33	.99	−.40	−1.20	298	390	−92	58	87.0
Rice	380	2.03	.08	.24	−.06	−.18	15,292	15,314	−22	185	277.5

Yugoslavia											
Wheat	177	.54	.28	.75	−.12	−.37	5,979	5,118	861	25	37.5
Maize	185	.71	.24	.72	−.17	−.52	9,106	8,647	459	37	55.5
Beef	1,832	1.08	.20	.60	−.40	−1.20	326	266	60	40	60.0
Argentina											
Wheat	136	.54	.25	.75	−.05	−.15	11,000	7,736	3,264	25	50.0
Rice	194	.81	.27	.82	−.10	−.30	309	222	87	78	156.0
Maize	118	.49	.22	.67	−.11	−.33	5,855	2,775	3,080	55	110.0
Beef	927	.72	.25	.75	−.20	−.60	2,811	2,410	401	18	36.0
Egypt											
Wheat	166	.48	.12	.37	−.17	−.52	1,960	4,878	−2,918	220	508.0
Rice	375	.35	.25	.75	−.12	−.37	2,300	2,089	211	360	520.0
Maize	171	.52	.06	.18	−.12	−.37	3,047	3,506	−459	240	480.0
Cotton	2,397	.34	.05	.15	−.10	−.30	396	231	165	8,440	10,000.0
Pakistan											
Wheat	152	.78	.17	.53	−.20	−.60	8,691	9,877	−1,186	247	533.0
Rice	320	.57	.15	.45	−.15	−.45	4,106	3,324	782	290	350.0
Maize	171	.94	.10	.30	−.17	−.52	764	764	0	300	480.0
Cotton	876	.58	.82	2.47	−.10	−.30	418	305	113	2,240	3,950.0
Thailand											
Rice	218	.74	.07	.22	−.03	−.07	15,068	13,143	1,925	400	580.0
Maize	115	1.02	.10	.30	−.05	−.15	2,675	287	2,388	240	480.0
Sugar	298	1.65	.08	.24	−.15	−.45	1,757	633	1,124	338	507.0
Rubber	695	.49	.09	.28	−.00	−.02	400	27	373	54	81.0

[a] Nominal protection coefficient.
[b] These coefficients represent distortions in production only; the corresponding NTCs in consumption are 1.18 for wheat and .90 for barley.

Table 2. Real Effects of Price Distortions, 1976

Country / Commodity	Estimated Change in Production		Estimated Change in Consumption		Estimated Change in Exports		Estimated Change in Agricultural Employment: Average Coefficients		Estimated Change in Agricultural Employment: Marginal Coefficients	
	Low	High	Low	High	Low	High	Low	High	Low	High
	('000 metric tons)						(Full time workers)			
France										
Wheat	1,400	4,266	−161	−482	1,560	4,748	17,821	54,302	26,731	81,454
Maize	225	689	−212	−637	438	1,326	4,239	12,980	6,358	19,470
Barley	1,005	3,063	−158	−474	1,163	3,538	12,793	38,989	19,189	58,484
Sugar	625	1,881	−61	−183	685	2,064	16,548	49,802	24,822	74,704
Beef	77	232	−127	−381	204	613	1,568	4,725	2,352	7,088
Germany, F.R.										
Wheat	926	2,821	338	715	1,164	3,537	10,000	30,464	15,000	45,697
Maize	30	92	−274	−823	304	915	479	1,470	719	2,206
Barley	920	2,804	−269	−808	1,189	3,612	9,935	30,281	14,903	45,421
Sugar	511	1,546	−90	−270	601	1,815	11,478	34,727	17,217	52,090
Beef	81	242	−149	−446	229	688	1,400	4,181	2,099	6,772
United Kingdom										
Wheat	291	878	−110	−329	400	1,207	3,206	9,674	4,809	14,511
Maize	0	1	−163	−488	163	489	0	16	0	24
Barley	36	108	−8	−24	44	132	397	1,190	595	1,785
Sugar	46	138	−72	−215	118	353	1,054	3,163	1,581	4,744
Beef	31	93	−60	−180	91	272	546	1,639	820	2,459
Japan										
Wheat	114	135	−74	−221	188	566	2,513	7,604	3,769	11,406
Barley	114	345	18	53	96	292	2,513	7,604	3,769	11,406
Sugar	31	95	−87	−261	118	356	1,392	4,265	2,088	6,398
Beef	23	68	−36	−108	59	176	544	1,610	817	2,415
Rice	6,207	18,622	−466	−1,399	7,606	20,020	468,692	1,406,151	703,038	2,109,227

Yugoslavia										
Wheat	−1,273	−3,820	523	1,613	−1,796	−5,433	−12,990	−38,980	−19,485	−58,469
Maize	−893	−2,678	600	1,837	−1,493	−4,515	−13,486	−40,443	−20,229	−60,665
Beef	5	14	−8	−24	13	38	82	229	122	343
Argentina										
Wheat	−2,343	−7,028	329	988	−2,672	−8,016	−19,525	−58,567	−39,050	−117,133
Rice	−20	−59	5	16	−25	−75	−520	−1,534	−1,040	−3,068
Maize	−1,341	−4,083	318	953	−1,658	−5,036	−24,585	−74,855	−49,170	149,710
Beef	−273	−820	187	562	−461	−1,382	−1,638	−4,920	−3,276	−9,840
Egypt										
Wheat	−255	−786	898	2,748	−1,153	−3,534	−18,700	−133,096	−43,180	−133,096
Rice	−1,068	−3,204	466	1,435	−1,533	−4,639	−128,160	−384,480	−185,120	−555,360
Maize	−169	−506	388	1,197	−557	−1,704	−13,474	−40,480	−26,987	−80,960
Cotton	−38	−115	45	135	−83	−250	−106,907	−323,533	−126,667	−383,333
Pakistan										
Wheat	−417	−1,299	557	1,671	−974	−2,971	−34,333	−106,951	−74,087	−230,789
Rice	−465	−1,394	376	1,128	−841	−2,522	−44,950	−134,753	−54,250	−162,633
Maize	−5	−15	8	25	−13	−40	−500	−1,500	−800	−2,400
Cotton	−248	−748	22	66	−270	−814	−185,173	−558,507	−326,533	−984,867
Thailand										
Rice	−371	−1,165	139	323	−509	−1,488	−49,467	−155,333	−71,727	−225,233
Maize	5	16	0	−1	6	17	400	1,280	800	2,560
Sugar	55	166	−37	−112	93	278	6,197	18,703	9,295	28,054
Rubber	−37	−117	0	1	−37	−117	−666	−2,106	−999	−3,159

On the other hand, the picture is reversed with respect to consumption. Developing countries consume more and developed countries less than they would in the absence of price intervention measures. Thus the pricing policies clearly have a beneficial effect in terms of providing more food for the nonagricultural population in developing countries. However, assuming that this result is one of the policy objectives of price intervention, it is achieved at the expense of the agricultural sector.

The effects on trade are merely a combination of the effects on production and consumption, since stocks are assumed to be constant. In general, we find that the pricing policies cause a reduction in the exports of developing countries (for exported commodities with NPCs smaller than 1) and a lessening of imports by the industrialized nations (for imported commodities with NPCs larger than 1). In the case of imports by developing countries with NPCs of less than 1, these imports are increased by the sum of the absolute values of the effects on production and consumption. Such a situation implies government subsidies, for example, in Egypt for wheat and maize. (Parts of the imports may not be subsidized directly by the government of Egypt but may be the result of shipments at concessionary terms.) On the other hand, export commodities with NPCs larger than 1 imply that dumping is taking place and that export subsidies are necessary to bridge the gap between the internal price and world market price. All five commodities analyzed for France show the effects of this policy.

On the basis of a small sample of countries it is difficult to determine what the aggregate effects of agricultural policies are at the world market level. Even for a standard case in which developing countries are exporters using export taxes and where developed countries are importers with positive rates of protection, the sign of the impact on the world market price cannot be determined a priori, because both net exports and net imports are being reduced at the same time. Hence, it would be necessary to analyze the policies of all trading countries simultaneously for a particular commodity before the world market price impact could be estimated.

Employment/Migration Effects

The process of economic development typically is associated with internal migration from the primary sector in rural areas to industrial and service sectors in urban centers. Economic theories on internal migration attribute this shift as a response to differences in employment opportunities between regions. Potential migrants evaluate costs and benefits associated with relocation and make their decision accordingly. A primary determinant in their decision is the relative income opportunities in rural versus urban locations (Falaris). In spite of (or because of) massive development efforts over the last decade, rural poverty persists in many parts of the world,[5] and recent work has demonstrated that low real-income levels of farm households have in some cases declined (Rajaraman) at the same time that various price-support measures are maintaining farm incomes in other parts of the world.

A common explanation for rural poverty is that agricultural productivity is low because of tenancy arrangements and limited access to modern inputs and techniques such as controlled irrigation, chemical fertilizers, pesticides, mechanization, new varieties of crops, credit, and extension services. Such explanations ignore the effect that product prices have on agricultural productivity and, therefore, on employment and migration. Here we attempt to quantify the extent to which product prices that are undervalued contribute to a suboptimal rural population and the extent to which product prices that are overvalued contribute to a larger-than-optimal rural population.

In Table 2 we present four estimates of the impact of price distortions on agricultural employment. Two are based on average labor/output coefficients, using production changes calculated from high and low supply elasticity estimates. The other two are calculated using marginal labor/output coefficients where production changes are based on high and low supply elasticities. There are three reasons for presenting the results in this manner. First, we wish to demonstrate the sensitivity of employment to changes in assumptions. Second, labor coefficients tend to be rather gross estimates, as they are derived from numerous secondary sources that use different assumptions and they typically vary by more than 100% within developing countries according to different production techniques for the same crop. Our results may be regarded as captur-

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[5] ". . . the most promising attack on employment problems in developing countries is in efforts to redress the present urban bias in development strategies" (Edwards).

ing the upper and lower bounds of employment changes. Third, it can be argued that under a regime of distorted prices, marginal operators will be displaced or expanded in response to price changes. Thus, marginal labor/output coefficients are more appropriate for estimating impacts on agricultural employment.

Referring to the developed countries in table 2, we see that existing agricultural pricing policies cause significant numbers of workers to remain in agriculture. Japanese rice-pricing policies are particularly significant, causing from between one-half of a million workers (low supply elasticity, average coefficient) to 2 million workers (high supply elasticity, marginal coefficient) to stay in agriculture. As a proportion of farm population, the numbers are large (2.1% to 9.6%); expressed as a proportion of total population (0.4% to 1.9%), the numbers are still significant. In the European countries presented here, the number of workers retained in agriculture is somewhat smaller, both absolutely and relatively. For example, in France, if free-market prices were to prevail for all five commodities, between 52,987 and 241,200 workers in an agricultural labor force of 8.6 million would be displaced.[6] In terms of the total work force, the proportion is 0.16% to 0.75%. While this percentage may seem rather small, it is nonetheless significant.

In developing countries, agricultural price distortions have the effect of reducing farm employment from that which would exist under free market prices. In general, the absolute value of the effects on employment is larger for developing than for developed countries, partly because of the labor-intensive production methods used in developing countries. The numbers suggest the extent to which price distortions create unemployment and stimulate migration. Using the high supply elasticity and marginal labor coefficients in Egypt, for example, the total reduction in agricultural employment for the four commodities is 1.15 million workers, or around 5% of the rural population. Employment in rice production accounts for a large portion of this. No doubt the numbers would be considerably larger if secondary (multiplier) effects were considered and if all commodities were covered.

Unemployment and rates of rural-to-urban migration greater than the rates of urban job creation are serious problems in developing countries. While overt unemployment is pronounced in urban centers, disguised unemployment is prevalent in rural areas (Todaro). Thus, any policies that contribute to unemployment or underemployment, such as agricultural pricing policies, need to be examined carefully. The conventional lay wisdom that if prices for farm products were to be increased in developing countries, poor people would be hurt, needs to be scrutinized. Many of the poor are rural poor or former rural residents who have migrated to urban areas in search of better employment opportunities. Higher agricultural prices would assist them if they were to remain as farmers, landless laborers, or farm-related workers. Viewed in a longer-run dynamic context, as farmers and farm laborers realize higher incomes, their demand for urban-produced goods and services will increase, so stimulating employment in urban areas.[7]

Welfare Effects

Our results indicate that the economies of the countries analyzed incur large annual welfare losses due to a misallocation of resources resulting from the existing agricultural pricing policies (table 3). The losses depend linearly on assumed elasticities and quadratically on the size of the price distortion as measured by a proportional tariff rate. Total net social losses are the sum of net social losses in production and in consumption. They range from U.S. $26 million for the United Kingdom (the low elasticity case) to U.S. $4,119 million for Japan (the high elasticity case). Even though the sample of commodities used in this analysis is small, it is interesting to compare the estimated welfare losses to the GNP of the countries.[8] The results show that in comparison with economic output, distortions are generally more costly to developing countries than to industrialized nations (table 4). Compared to agricultural gross national product (GNP), however, the comparative losses of the different countries are somewhat more evenly distributed when the importance of the agricultural sector in the total economy is taken into account.

The results have been obtained from a par-

[6] We do not wish to render the labor estimates useless by presenting numbers which have such a large variance, but we do want to present realistic upper and lower bounds.

[7] We are indebted to Willis Peterson for suggesting this point.

[8] By selecting only four or five major agricultural commodities here, we clearly underestimate the effects of the price distortions in the agricultural sector. Thus, our figures represent lower bounds of the true effects.

Table 3. Net Social Losses of Price Distortions, 1976 (in '000 US dollars)

Country Commodity	Net Social Loss in Production		Net Social Loss in Consumption		Total Net Social Loss	
	Low	High	Low	High	Low	High
France						
Wheat	26,020	79,298	2,986	8,959	29,006	88,258
Maize	5,310	16,244	5,002	15,006	10,313	31,250
Barley	26,854	81,840	4,225	12,676	31,079	94,515
Sugar	31,586	95,148	3,079	9,238	34,665	104,386
Beef	24,721	74,163	40,530	121,589	65,251	195,752
Total	114,491	346,693	55,822	167,468	160,314	514,161
Germany, F.R.						
Wheat	32,341	98,839	8,355	25,066	40,696	123,905
Maize	1,266	3,948	11,721	35,164	12,988	39,112
Barley	32,147	97,973	9,408	28,223	41,555	126,196
Sugar	56,883	171,973	10,006	30,018	66,889	201,990
Beef	33,405	100,214	61,456	184,369	94,861	284,583
Total	156,042	472,947	100,946	302,840	256,989	775,786
United Kingdom						
Wheat	3,400	10,272	1,285	3,854	4,685	14,126
Maize	4	11	2,985	8,955	2,988	8,965
Barley	23	71	5	16	29	87
Sugar	2,541	7,623	3,961	11,882	6,502	19,506
Beef	4,053	12,158	7,845	23,536	11,898	35,694
Total	10,021	30,135	16,081	48,243	26,102	78,378
Japan						
Wheat	19,567	58,946	1,254	3,763	20,821	62,709
Barley	19,602	59,051	140	420	19,742	59,471
Sugar	1,715	5,225	4,789	14,367	6,504	19,592
Beef	7,666	22,998	12,161	36,482	19,827	59,480
Rice	2,035,883	3,644,244	91,237	273,712	2,127,120	3,917,956
Total	2,084,433	3,790,464	109,581	328,744	2,194,014	4,119,208
Yugoslavia						
Wheat	51,836	155,509	21.298	65,670	73,135	221,179
Maize	23,945	71,836	16.106	49,266	40,051	121,102
Beef	354	1,062	578	1,733	931	2,794
Total	76,135	228,407	37,982	116,669	114,117	345,075
Argentina						
Wheat	73,276	219,829	10.307	30,920	83,583	250,749
Rice	361	1,095	96	288	457	1,383
Maize	40,341	122,856	9.560	28,680	49,901	151,536
Beef	35,468	106,403	24.327	72,980	59,794	179,383
Total	149,446	450,183	44.290	132,868	193,735	583,051
Egypt						
Wheat	10,997	33,908	38 773	118,601	49,771	152,509
Rice	130,145	390,435	56 739	174,944	186,884	565,380
Maize	6,926	20,777	15 938	49,143	22,864	69,920
Cotton	30,403	91,208	35 470	106,409	65,873	197,618
Total	178,471	536,328	146 920	449,097	325,392	985,427
Pakistan						
Wheat	6,968	21,723	9.316	27,947	16,283	49,670
Rice	31,966	95,899	25.878	77,635	57,845	173,534
Maize	25	75	43	130	68	205
Cotton	45,660	137,536	4 063	12,189	49,723	149,725
Total	84,619	255,233	39 300	117,901	123,919	373,134
Thailand						
Rice	10,503	33,008	3 926	9,161	14,429	42,169
Maize	6	18	0	1	6	19
Sugar	5,363	16,088	3.623	10,868	8,985	26,956
Rubber	6,641	20,659	0	100	6,641	20,759
Total	22,513	69,773	7.549	20,130	30,061	89,903

Table 4. Estimated Total Net Social Losses as a Percentage of GNP for Some Countries and for a Selected Commodity Sample, 1976

	Agricultural GNP[a] (as % of GNP)	Social Losses (% of GNP)		Social Losses (% of Agricultural GNP)	
		Low	High	Low	High
France	5	0.05	0.16	1.0	3.2
Germany	3	0.06	0.19	2.0	6.3
United Kingdom	3	0.01	0.04	0.3	1.3
Japan	5	0.43	0.80	8.6	16.0
Yugoslavia	16	0.34	1.03	2.1	6.4
Argentina	13	0.48	1.46	3.7	11.2
Egypt	28	3.52	10.58	12.6	37.8
Pakistan	33	1.01	3.04	3.1	9.2
Thailand	27	0.21	0.62	0.8	2.3

[a] World Bank 1979.

tial equilibrium model and hence capture only partial effects. However, it is clear that distortions of the size discussed here would have repercussions in other sectors of the economy as well. Thus, a general equilibrium analysis would produce estimates of social costs larger than those estimated here.

As our results in table 5 indicate, the most sizeable effects of the different agricultural policies are the welfare transfers between consumers and producers. While the farm sector in the developing countries studied was taxed from about $700 million to about $2 billion annually, the producers in developed countries received large transfers due to the protectionist policies. In Japan, where the average rate of protection is the highest, farmers gained between $2.6 and $5.1 billion for the total of the five major commodities analyzed. (See Bale, who estimates the producer gain to farmers for these products, except sugar, at $5.29 billion in 1975/76.) Consumers in developed countries incurred large welfare losses because of price protection whereas the consumers in developing countries generally gained from this type of price intervention. Relating the magnitudes of the welfare transfers to the size of the social losses, it is apparent that the transfers are far more sizeable than the deadweight losses.

Our results indicate that, with the exception of France, governments in all countries received increased revenues from their interventionist policies. These results are based on the implicit assumption that the entire price distortion is attributable to taxes (or subsidies). In reality, however, quantitative restrictions also are used, and unless the quotas are auctioned, the quota recipient gets the revenue. So, in general, our results tend to overestimate government revenues. Exceptions are those countries that import commodities with NPCs of less than one (e.g., wheat in Pakistan), in which case our method assumed implicitly that the entire distortion is due to government subsidies. To the extent that imports at concessionary terms are involved, our results underestimate actual government receipts.

The effects on foreign exchange earnings are again clearly divided according to different levels of development. While industrialized nations gained foreign exchange through protectionist policies, developing countries lost foreign exchange earnings. This is particularly serious in that foreign exchange availabilities represent a major bottleneck for developing countries in their efforts to increase growth and alleviate poverty.

Limitations

Two caveats need to be made in order to insure proper interpretation of our results. First, the results are based on only one year—1976. Second, in certain cases the quality of the data is uncertain and some personal judgments were required. Because of the uncertainties involved, range analysis was used to ascertain the sensitivity of the results to different data input. We regard the results as providing orders of magnitude rather than exact measures. As indicated by the range analysis, the qualitative conclusions are stable with respect to different elasticity assumptions. Methodological questions were addressed in a previous section.

Table 5. Monetary Effects of Price Distortions 1976 (in '000 U.S. Dollars)

Country Commodity	Welfare Gain of Producers		Welfare Gain of Consumers		Change in Government Revenue	Change in Foreign Exchange Earnings	
	Low	High	Low	High		Low	High
France							
Wheat	574,437	521,159	−292,433	−298,405	−311,011	223,124	678,904
Maize	258,703	447,769	−216,382	−226,387	−52,633	66,533	201,615
Barley	428,904	373,918	−305,410	−313,861	−154,573	159,379	484,695
Sugar	269,234	205,672	−201,030	−207,188	−102,870	198,088	596,491
Beef	1,138,079	1,088,637	−1,129,896	−1,210,955	−73,433	483,337	1,450,011
Total	2,669,357	2,437,155	−2,145,151	−2,256,796	−694,520	1,130,461	3,411,716
Germany							
Wheat	437,178	370,771	−516,503	−533,214	38,539	166,477	505,734
Maize	39,774	37,092	−334,569	−358,012	281,808	45,571	137,236
Barley	421,099	355,273	−565,481	−585,296	103,827	162,961	494,886
Sugar	551,291	436,202	−585,023	−605,035	−33,157	173,738	524,650
Beef	1,095,996	1,029,187	−1,243,775	−1,371,688	57,918	451,720	1,355,159
Total	2,545,338	2,228,525	−3,251,351	−3,453,245	448,935	1,000,467	3,017,665
United Kingdom							
Wheat	107,516	100,644	−193,289	−200,859	86,089	62,462	188,350
Maize	70	63	−139,434	−145,404	136,376	21,346	64,038
Barley	10,072	10,024	−10,692	−10,703	591	5,756	17,368
Sugar	79,795	74,713	−286,287	−294,209	199,990	33,343	100,029
Beef	274,864	266,759	−316,384	−332,075	29,622	139,976	419,928
Total	472,317	452,203	−95[illegible],086	−983,250	452,668	262,883	789,713
Japan							
Wheat	56,377	16,998	−206,837	−209,346	129,639	35,532	106,974
Barley	52,302	12,853	3[illegible],396	31,116	−103,440	15,360	46,720
Sugar	59,975	56,464	−333,727	−343,305	267,248	36,131	108,846
Beef	193,663	178,331	−273,645	−299,966	62,155	132,179	396,536
Rice	4,770,541	2,341,044	−6,085,137	−6,267,611	8,611	2,535,894	7,607,682
Total	5,132,858	2,605,690	−6,869,950	−7,089,112	364,213	2,755,096	8,266,758
Yugoslavia							
Wheat	−538,646	−642,319	395,409	351,038	70,103	−317,977	−961,647
Maize	−512,482	−560,372	447,805	414,645	24,625	−276,217	−835,184
Beef	47,425	46,717	−39,563	−40,718	−8,794	23,287	69,860
Total	−1,003,703	−1,155,974	805,651	724,965	85,934	−570,907	−1,726,971
Argentina							
Wheat	−761,436	−907,989	475,658	453,044	204,196	−363,404	−1,090,212
Rice	−11,750	−12,845	[illegible],087	7,895	3,207	−4,807	−14,561
Maize	−392,695	−475,210	157,440	138,320	185,354	−195,689	−594,259
Beef	−765,091	−836,027	60[illegible],213	552,560	104,084	−427,102	−1,281,307
Total	−1,930,972	−2,232,071	1,24[illegible],398	1,151,819	496,841	−991,002	−2,980,339
Egypt							
Wheat	−180,184	−203,095	382,296	302,468	−251,882	−191,425	−586,573
Rice	−690,770	−951,060	452,455	334,249	51,431	−575,027	−1,739,630
Maize	−257,024	−270,875	27[illegible],834	238,630	−37,675	−95,266	−291,333
Cotton	−656,883	−717,688	329,977	259,037	261,033	−199,614	−598,841
Total	−1,784,861	−2,142,718	1,436,562	1,134,384	22,907	−1,061,332	−3,216,377
Pakistan							
Wheat	−297,595	−312,350	32[illegible],971	302,340	−39,660	−148,031	−451,544
Rice	−596,952	−660,884	43[illegible],504	379,748	107,603	−269,044	−807,133
Maize	−7,864	−7,914	7,796	7,709	0	−2,252	−6,838
Cotton	−199,450	−291,327	10[illegible],153	100,027	41,575	−236,776	−712,978
Total	−1,101,861	−1,272,475	86[illegible],424	789,824	109,518	−895,665	−1,978,493
Thailand							
Rice	−864,557	−887,062	74[illegible],019	735,784	109,109	−110,989	−324,376
Maize	6,146	6,134	−660	−661	−5,492	636	1,907
Sugar	334,968	324,243	−126,235	−133,480	−217,719	27,647	82,942
Rubber	−148,421	−162,439	9,570	9,471	132,210	−26,041	−81,408
Total	−671,864	−719,124	623,694	611,114	18,108	−108,747	−320,935

Conclusions

What emerges from this paper is the vital role that farm product prices play in achieving optimum output and growth in productivity. Because "incorrect" price signals are being given to farmers, full potential in terms of allocation, production, and consumption is not being realized. In many cases, the estimated changes in production have greatly altered trade patterns, in some cases causing importing countries to become self-sufficient, in other cases causing "would-be exporters" to become importers. Particularly the magnitude of income transfers but also that of the efficiency losses (net social losses) are significant, both as an absolute number and as a proportion of national and agricultural income. The effects of price distortions on rural employment, while perhaps less impressive than the welfare losses, are nonetheless serious, given the high unemployment rates in developing countries and the political sensitivity of agricultural employment in developed countries. Since we have not considered distortions in the input markets our analysis may overestimate or underestimate the true welfare effects depending on the nature of the input distortion (subsidies or taxes) and whether the nominal protection coefficients are greater or less than one.

The ultimate question about agricultural pricing policies is their long-term dynamic effects. In this paper we have quantified the static effects. Our model (and the state of technology of our profession) did not allow us to estimate accurately the effects on income and industrial growth, adoption of technology, investment in agriculture, social consequences, and others. While it is politicians and not agricultural economists who make the decisions for governments, our profession plays a vital role in defining and quantifying the issues involved, and in passing these findings to appropriate officials. Our hope is that this paper is in keeping with that tradition.

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A Multicommodity Analysis of Trade Policy Effects: The Case of Nicaraguan Agriculture

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Agricultural trade policies for a small country are analyzed, using a simple, multicommodity, quadratic programming, agricultural sector model. The policy conditions simulated include (*a*) quantitative trade restrictions given an uncertain world market, (*b*) export taxation, and (*c*) import subsidies. The multicommodity, sectoral-wide coverage permits analysis of the factor-product market linkages and enables identification of the distributional consequences.

Key words: Nicaragua, quadratic programming, sector modeling, trade policy, uncertainty.

Agriculture must play a number of competing roles in a developing country. As well as producing food for a growing nonfarm sector, it also must play a large role in generation of foreign exchange, employment, and gross national product (GNP). This can result in a number of policy conflicts. On the one hand, governments frequently attempt to hold food prices artifically low to protect the real income position of urban consumers. On the other hand, farmers must be provided adequate incentive to produce both domestic food and exportables. One area in which conflict does arise is trade policy.

International trade theory suggests that the optimum trade policy for a small open economy under certainty is free trade. Any distortion of domestic relative prices away from the international terms of trade results in a social welfare loss in that country. However, given an uncertain and variable world market, the welfare benefits gained from trade may be accompanied by less stable domestic markets. Many less developed countries (LDCs) have adopted restrictive trade policies to dampen the effects of world price uncertainty on their domestic economies. The demands of the LDCs in the current trade discussions for world commodity price stabilization (Warley) are partly in response to volatile world prices.

Most empirical studies of trade policy and other costs of protection have been carried out in a partial equilibrium framework, one commodity at a time, with all other prices and real income held constant. Even when carried out for a number of commodities in the same economy, the analyses usually are done one commodity at a time, ignoring the interrelationships (simultaneities) among the commodities in both production and consumption (as in Bale and Greenshields). Factor market and functional income distribution adjustments, which often are ignored, are in reality just as often the crux of the argument in trade policy considerations. The objective of this paper is to present and illustrate the use of a simplified model of a small, open economy for obtaining approximate estimates of the effects of trade and policy distortions. The model encompasses production of multiple commodities from multiple factors. A second objective of this paper is to examine the effects of trade restrictions on domestic market stability.

To achieve these objectives a simple, open, fifteen-commodity, quadratic programming model of the Nicaraguan agricultural sector is constructed. The model includes farm production, processing and trading activities, domes-

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tic demand, labor and land supply, credit, and other input use. Three policy simulations are carried out with the model, and the effects on all of these variables are estimated. First, because Nicaragua imposes formal and informal quantitative restrictions on trade, which cut the link between domestic and world market prices, the effects of removing these quotas are simulated. Further, because one of the objectives of imposing quantitative restrictions is domestic price stabilization, the impact of the existing restrictions and their removal is simulated with eight different years of world price data. Second, the effects of imposing an export tax such as was used to generate tax revenue following the 1972 earthquake are simulated. Third, the effects of agricultural input subsidies are simulated. The comparative statics effects on equilibrium quantities and prices in both product and factor markets and distributional effects are presented.

Background

Like many LDCs, Nicaragua is a small, open economy which derives a large portion of its foreign exchange earnings (60%) from agricultural exports; yet it does not export a sufficient quantity of any one product to be able to affect the world terms of trade. The agricultural sector can be dichotomized into two production subsectors: production primarily for domestic consumption and production primarily for export. The two subsectors, however, are quite different, with the export subsector using 88% of the imported agricultural inputs (Warnken) and being characterized by larger landholdings. This segmentation in production has led to the formation of separate subsectoral economic policies.

The principal crops of the Nicaraguan agricultural subsector are export crops—cotton, coffee, tobacco, sesame, and sugarcane; and domestically consumed crops—rice, corn, beans, and sorghum. Cotton, sugarcane, and rice are processed before sale, yielding ginned cotton and cottonseed, sugar, and milled rice. Bananas, although important, will not be treated in this analysis because of a lack of data. Crop production, acreage, domestic price, domestic consumption, export price, and export quantity for 1971 are presented in table 1. In some cases, these data reveal a gap between domestic and export price. Sugar and coffee are traded under a system of international quotas. The other crops are exported through an informal system of quotas (Cappi et al.).

Method

This analysis is carried out with a multicommodity agricultural sector model that explicitly includes the factor markets. This model is designed to simulate a competitive agricultural sector and to reflect the product

Table 1. 1971 Nicaraguan Production Statistics

Commodity	Land[a]	Production[b]	Domestic Consumption[b]	Domestic Price[c]	Export[b]	Export Price[c]	Imports	Import Price
Coffee	150	928	224	247	704	291	0	—
Tobacco habano	0.7	18	0.9	1,224.1	17.1	1,300	0	—
Tobacco rubio	1	26	26	251.8	—	—	0	—
Sesame	9.6	103	15	72.5	88	100	0	—
Sugarcane[d]	46	38,960	0	1.75			0	—
Sugar[e]		3,507	1,812	52	1,694	53	0	—
Irrigated rice[d]	11	545	—	40	—	—	0	—
Nonirrigated rice[d]	19	307	—	40	—	—	0	—
Milled rice[e]	—	530	347	67.5	183	68	0	—
Raw cotton[d]	136	5,063		56.7	—	—	0	—
Ginned cotton[e]	—	1,736	159.4	159.4	1,687	171	0	—
Cottonseed[e]	—	2,795	2,598	20.3	197	28	0	—
Corn	236	3,539	3,581	34.4	134	35	175	33
Beans	45	336	128	76.8	236	77	28	78
Sorghum	39	51.7	534	25.6	8	26	25	25

[a] In thousands of manzanas (one manzana = 1.74 acres).
[b] In thousands of hundredweights.
[c] In cordobas per hundredweight (one cordoba = U.S $ 1428).
[d] A commodity to be processed.
[e] A commodity after processing.

and factor market impacts of trade distortions. The model is a quadratic programming model of the type introduced by Takayama and Judge and discussed in the recent review paper by McCarl and Spreen.

The model simulates activity within the Nicaraguan agricultural sector involving production, processing, export, import and domestic consumption of sesame, corn, beans, cotton, rice, coffee, sorghum, tobacco rubio, tobacco habano, and sugarcane. Other commodities are treated as exogenous. Operationally, the model maximizes the area between the supply and demand curves subject to supply-demand balance, foreign trade, and resource constraints.

The objective function consists of the area under the domestic demand curve plus export revenue minus the costs of imports, miscellaneous production, credit, chemicals, and processing. The areas under the land and labor supply curves are also subtracted. Constraints are present which balance (*a*) total land use with land supplied, (*b*) labor use with labor supply (from both family and hired sources), (*c*) credit use with credit supply, (*d*) chemical use with chemical supply, and (*e*) product use with product supply. Constraints are also present which limit processing capacity and impose export-import quotas. Fajardo provides details on model specification (the authors also will provide a detailed specification upon request).

Assumptions and Empirical Specification

Several key assumptions are made relative to the sector. First, labor is assumed to be in infinitely elastic supply up to a point, 20% more than current use. It then follows a linear supply curve from that point on, with point elasticity 2. This practice is followed because of the high degree (30%) of rural unemployment (Warnken) and because of a lack of data to utilize other possible assumptions. Second, production of each crop is modeled with only one production activity. Third, it is assumed that the supply curve of land is upward sloping, reflecting a progressively higher cost of either drawing land out of other enterprises (exogenous to the model) or developing additional land. Fourth, credit is modeled with a differential interest rate for each crop, reflecting current conditions in the Nicaraguan sector. Fifth, all other inputs are modeled as infinitely available at a price. These assumptions will not be discussed at great length here and are made on the basis of data availability and knowledge of the sector. (See Fajardo for a thorough discussion of these assumptions.) The way these assumptions are implemented is presented below.

Empirical specification of the model is accomplished using the approach of Miller and Millar. Rather than being built up from micro data, the model is constructed using national average farm budget data (Warnken). The model is empirically forced to reproduce the observed 1971 data, assuming that the sector was in equilibrium during that year. This is similar to the approach that is often used in input-output analysis. The production and processing budgets are normalized on land area or processing level. Use of each input explicitly accounted for in the model (land, labor, credit, fertilizer, and pesticides) is then priced at its 1971 observed price, as is production of each output. The miscellaneous cost item in each budget is then set at the difference between the budget's total cost and total revenue. As a result, at prevailing 1971 prices, marginal revenue and marginal costs of any given activity are equal. This is the condition of optimality for the QP model.

Completion of the model also requires specification of commodity demand, land supply, and hired labor supply schedules. Demand for each commodity is assumed to be represented via a negatively sloped function. Price elasticities are obtained either by manipulating income elasticities (via Frisch's method) or from related work in Mexico (Duloy and Norton). Cross-price elasticities are not included. The linear demand curve formed for each commodity has a prespecified elasticity at the point given by the base-period price and quantity. With respect to foreign trade, Nicaragua is assumed to be a small country facing infinitely elastic (fixed-price) world market supply and demand schedules for all products. Export and import prices are fixed at their 1971 levels, as seen in table 1. Quantitative export and import restrictions are either set at their 1971 levels (as in table 1) or are not effective restrictions.

The land supply is specified in a similar manner. By inspection of the ranges of annual land costs in Warnken, a price of 100 cordobas per manzana is chosen as the base land price. The base quantity of land is the total acreage of crops planted in 1971. A land supply elastic-

ity of +0.2 is chosen, based upon the authors' judgment. A linear land supply curve is therefore included with an elasticity of 0.2 at the 1971 price-quantity point. Credit cost (which varied by crop) is drawn from Central Bank of Nicaragua statistics. Labor cost is set at the national average agricultural wage rate. Fertilizer and pesticide costs are held at 1971 average cost.

Model Verification

The data used in the model specification were from 1971. Thus, the task became to reproduct 1971 economic performance. The model specified above was run without trade restrictions and showed quite a large gap between the actual and predicted outcomes. This difference principally arose in the foreign sector where exports were considerably larger than the observed levels. Domestic consumption was lower than observed. This occurred because in the model, with no barriers to trade, domestic and export or import prices are equal for traded goods. This is inconsistent with the observed divergence between domestic and export prices as given in table 1. An examination of the literature (Cappi et al.) and the authors' experience led to the conclusion that exports are traded under formal and informal quotas.[1] Thus, quantity limits on exports and imports were imposed at 1971 levels and the model was rerun. These results are presented in table 2. Comparing table 2 with table 1, extremely close correspondence was obtained between the trade restricted model and 1971 reality, as expected (given the model specification approach). This model, judged to reproduce adequately 1971, is adopted for further analysis of changes under specified conditions.[2]

Experiments and Results

Perhaps the most interesting question to be answered is what would happen if Nicaragua's agricultural sector were opened to unrestricted foreign trade. This analysis is presented below, as are other analyses on export taxation and import pricing options.

[1] Two alternative hypotheses also can be advanced. First, the model may be misspecified, and the difference between domestic and foreign prices should be considered a marketing margin. Second exporters may be risk-averse; and, thus, risk attitude would explain the difference. The first hypothesis was believed false. The second hypothesis was tested using a Hazell and Scandizzo-type risk model; however, the results were not significantly better and, therefore, are not discussed here.

[2] This procedure does not test the validity of the model for the analysis of changes from the equilibrium. Rather, the model is assumed valid by construction.

Table 2. Base Model Production Results

Commodity	Land[c]	Production[d]	Domestic Consumption[d]	Domestic Price[e]	Exports[d]	Imports[d]
Coffee	150	928.7	224	247.9	704	0
Tobacco habano	0.7	18.0	0.9	1,220	17.1	0
Tobacco rubio	1.0	26.3	26.3	251.8	0	0
Sesame	9.6	103.5	15.5	72.5	88	0
Sugarcane[a]	46.3	38,944	—	1.75	—	—
Sugar[b]	—	3,505	1,811	52.2	1,694	0
Irrigated rice[a]	11.2	535.9	—	40.1	—	—
Nonirrigated rice[b]	19.3	310.1	—	40.1	—	—
Milled rice[b]	—	530	347	67.4	183	0
Raw cotton[a]	136.3	5,063	—	64.5	—	—
Ginned cotton[b]	—	1,737	50	159.1	1,687	0
Cottonseed[b]	—	2,795	2,598	20.3	197	0
Corn	236	3,539	3,531	34.4	134	17.6[f]
Beans	44.8	335.8	128	76.8	236	28[f]
Sorghum	39.1	51.7	534	25.6	8	25[f]

[a] Commodity which is processed before sale.
[b] Processed commodity.
[c] In 1,000 manzanas.
[d] In thousands of hundredweight.
[e] In cordobas per hundredweight.
[f] Both imports and exports are present for these commodities because of the quota structure.

Trade Restriction

Uncertainty in world prices is often cited as a major reason LDCs restrict, or want to impose restrictions on, trade. Quantitative restrictions on trade can aid in stabilizing domestic prices as they cut the link between domestic and world market prices. The model is used to analyze the consequences of restricted versus unrestricted trade under export price uncertainty in an attempt to estimate the magnitude of the dislocation arising from the imposition of quotas. Time-series data obtained on export prices for the three principal export crops—sugar, cotton, and coffee—for the years 1967–74 are given in table 3.

The comparison between unrestricted and restricted trade is made by first running the model with world market prices for each of the eight sample years with trade volumes restricted at 1971 levels and then running through each sample year with unrestricted trade. (Under these cases, the processing restraints were removed.) The results of this analysis are summarized in table 4.

In interpreting these results, several factors need to be considered. First, this is an equilibrium model, which fully adjusts to any shock within one year. Thus, the results do not take into account the perennial nature of some of the crops and other short-run resource fixities. Therefore, it overstates short-run resource adjustments among crops. Further, the formulation assumes that farmers react as if they had perfect knowledge of these prices and seek to maximize net income. The model is rather simple and does not capture risk-averse behavior, many constraints which may dampen adjustment, multiple activities for production of a crop, substitution in demand, or the effect on demand of income change—nor are the terms of trade adjustments captured which potentially would occur with large changes in the balance of trade. Consequently, the model can be said to give a maximum measure of the effects of international price stability (when tested under free trade). Nevertheless, the distributional effects of the price uncertainty are of interest.

The trade restrictions lower the average value of exports, depress rural employment, land prices, consumer prices, and producer prices (table 4). However, under restricted trade, all of these items were more stable, as expected.[3] The domestic consumer paid lower prices (as evidenced by the Laspeyres price index) and faced more stable prices. The producers of exported goods lost, as evidenced by their producer surplus.[4] Thus, the policy of export restrictions transfers income to consumers and producers of domestically consumed goods from export producers.[5]

Export Tax

One means implemented by the Nicaraguan government to obtain tax revenue after the

[3] Table 4 also illustrates one of the benefits of the multicommodity simultaneous trade-policy analysis. Land area is reallocated among crops in response to the policy change consistent with the opportunity costs of producing each crop.

[4] Consumer and producer surplus are used here individually and as a measure of welfare. These topics are somewhat controversial; also the zero cross elasticities cloud the use of this measure. However, the authors felt that in this context these measures were useful. Willig provides discussion and references.

[5] As Jabara and Thompson demonstrate, under risk aversion the subjective cost associated with international price uncertainty may exceed the static welfare losses identified here. But this is beyond the scope of the study.

Table 3. Export Prices for Cotton, Sugar, and Coffee, Nicaragua, 1967–74

	Cotton		Sugar		Coffee		
Year	Nominal[a]	Deflated[b]	Nominal[a]	Deflated[b]	Nominal[a]	Deflated[b]	Price Index[c]
1967	163.7	179.9	43.7	48.0	263.2	289.2	91.0
1968	183.4	205.6	44.3	49.7	256.5	287.5	89.2
1969	161.3	172.1	45.9	49.0	249.5	266.3	93.7
1970	162.6	170.3	47.3	49.5	345.5	361.8	95.5
1971	171.4	171.4	53.0	53.0	290.8	290.8	100.0
1972	199.0	173.9	57.3	50.1	324.0	283.2	114.4
1973	204.6	178.8	83.8	49.5	382.9	226.0	169.4
1974	331.8	145.6	81.6	35.8	459.5	241.1	227.9

[a] Cordobas per hundredweight (Source: Banco Central de Nicaragua, 1970, 1974).
[b] Price in 1971 constant cordobas.
[c] Based on FAO price index of agricultural commodities, FAO (1970–71 and 1974–75).

Table 4. Selected Results of Restricted Trade Analysis over Eight Years of Runs (1967–74)

	Unrestricted Trade		Traded under Quota	
	Mean	Coeff. of Variation	Mean	Coeff. of Variation
Production[a]				
Coffee	1,246	2.190	817	.284
Sugarcane	1,982	.005	2,248	.277
Raw cotton	26,582	.629	4,844	.120
Milled cotton	178	.005	181	.001
Ginned cotton	9,118	.629	1,661	.120
Selected export value[b]				
Coffee	373,648	2.645	172,116	.424
Milled sugar	0	—	11,223	2.646
Ginned cotton	1,659,315	.677	283,724	.180
Total exports value	2,612,357	.364	539,294	.196
Domestic price[c]				
Coffee	321	.084	246	.016
Milled sugar	582	.038	520	.006
Ginned cotton	178	.075	157	.029
Factor use				
Labor[d]	67,573	.596	34,292	.124
Land[e]	1,318,924	.176	675,305	.051
Fertilizer[b]	197,237	.710	86,596	.173
Insecticide[b]	366,612	.497	84,976	.102
Credit[b]	107,512	.425	28,541	.083
Miscellaneous				
Consumer and producer surplus[b]	3,287,220	.055	3,041,597	.013
Consumer surplus[b]	2,629,283	.023	2,814,392	.003
Producer surplus[b]	649,940	.369	227,091	.184
Exporter producer surplus[b]	477,850	.863	155,569	.158
Domestic producer surplus[b]	172,088	1.582	71,522	.439
Price of land[b]	0.549	.305	0.086	.786
Consumer price index	1.497	.111	0.991	.023
Producer price index	.985	.071	0.977	.066

[a] In thousands of hundredweight.
[b] In thousand cordobas.
[c] In cordobas per hundredweight.
[d] In thousands of man days.
[e] In thousands of manzanas.

1972 earthquake was the establishment of an ad valorem tax for export crops. The theory of commercial policy predicts that an export tax on a small (price-taking) country's exports will affect the market for a given good in one of two ways. Either (*a*) the volume of goods exported will fall as will the domestic price; or (*b*) if there is a binding export quota, it merely transfers income (rent) from exporters to the government (as tax revenues) with no changes in production of the good.

A 15% ad valorem export tax is imposed on exports of coffee, sugar, tobacco habano, cotton, and sesame. The solution is summarized under "Export Tax" in table 5. One of the most interesting findings is an observed reduction in the exports of only cotton and sugar. The tax equivalent of the existing export quotas on other crops already was causing more than a 15% difference between their domestic and export prices. Thus, case (*b*) above applied to these crops. In the new equilibrium under the taxes, less coffee was exported, and there were no sugar exports. The area of land planted to coffee fell slightly, and sugarcane land was almost halved. This led to a decrease in land value and a slight increase in the production of other crops. Total land use fell by 13%. Social welfare, measured by consumer plus producer surplus, fell 2.6%. A Laspeyres index of consumers' prices shows a 3.1% reduction, whereas an

Table 5. Principal Macroeconomic Results from Selected Alternatives

	1971 Actual	Base Model	Export Tax	Input Subsidy 1	Input Subsidy 2	Input Subsidy 3
Social welfare[a]	—	3,042,214	2,965,394	3,080,723	3,047,273	2,969,274
Producers' surplus[a]	—	231,598	140,621	260,906	232,609	142,618
Exporter producer surplus[a]	—	144,375	91,912	161,328	145,434	149,859
Consumers surplus[a]	—	2,810,429	2,824,817	2,818,897	2,813,754	2,826,702
Labor use[b]	36,059	36,069.62	32,515	36,148	36,102	32,646
Land use[c]	694.7	694.7	606.2	697	696.5	611.8
Credit[a]	274,678	287,346	201,973	287,443	287,177	263,574
Fertilizer[a]	101,058	97,947	86,084	98,158	98,008	91,274
Insecticide[a]	94,690	94,336	63,202	94,530	94,444	90,511
Price Consumer index[d]	—	100	96.9	97.8	99.2	96.4
Producer Price Index[d]	—	100	89.1	99.0	99.6	88.9
Government revenue[a]			50,532	−38,538	−5,001	73,972
Changes in social welfare from base[d]	—	—	−76,820	39,509	5,059	−72,940

[a] In thousands of cordobas.
[b] In thousands of man-days.
[c] In thousands of manzanas.
[d] Laspeyres' price index.

index of producers prices shows a 10.9% reduction. Consumers are slightly better off. Labor use fell by 10%. Government revenue from the tax was 74.7 million cordobas. This policy again benefits consumers and domestic producers while discriminating against exporters and reducing rural employment.

Imported Input Subsidies

The prices of imported inputs rose substantially in 1973. As a result, many LDCs subsidized the use of imported inputs. The effects of such a policy are simulated through the imposition of subsidy policies directed toward the chemical inputs.

Three subsidy policies are tested. The specific policies are (*a*) a 20% price subsidy on chemical inputs used for all crops, (*b*) a 20% price subsidy on chemical inputs used for only the domestically consumed crops, and (*c*) a 20% subsidy for domestically consumed crops coupled with a 15% export tax on the crops as above. The results from these three policies are summarized in table 5.

All of the subsidy policies resulted in gains for consumers. Producers gained under the all-crop subsidy policy, came out even under the domestic crop subsidy, and lost under the subsidy-tax policy. In all three cases the net change in government expenditures almost exactly equaled the gain in welfare. Government expenditures were 38.5 million cordobas under the first plan and 5.1 million under the second plan. Under the tax and subsidy program, net government receipts were 74 million cordobas.

Concluding Comments

This paper illustrates the use of a simplified multicommodity modeling approach that readily permits the analyst to conduct trade policy analysis taking into account important simultaneities often ignored in single-commodity analysis. The Nicaraguan crop sector is examined under selected changes in its trade and agricultural policies. The analysis uses a market-oriented, quadratic programming model of the crops sector. The model, constructed to reproduce 1971 conditions, is then used to test sensitivity of the sector to trade liberalization, unstable markets, export taxes, and imported input subsidies.

With regard to the Nicaraguan situation, several observations can be made. First, the production of export crops appears to be profitable, given the quotas in existence. Evidence for this appears in the form of the domestic-international trade differential. Trade in these commodities has been reduced through a system of quotas. Further, at times export taxes have been imposed, affecting export profitability while adding to government tax revenues. The analysis above shows that the net impact across all commodities of such policies is to bring about benefits to consumers and producers of domestically consumed crops, and losses to producers of crops that are primarily exported. Unrestricted trade increases rural employment, but also opens the country to considerably more variability in internal prices and incomes. Input subsidization policies also were examined, and the possibility was demonstrated that the revenues of an export tax might be used in subsidized domestic production.

Above and beyond concerns relating to the Nicaraguan context, this study raises a number of research questions. First, the model used is potentially powerful. The alternative to this model is a larger, more data-intensive model, such as CHAC (Duloy and Norton). The time required to implement the model in this paper can be much less; however, the accuracy of the larger model could (and should) be greater. The research questions that arise, then, are: How accurate is the type of approach used herein? Is this approach inappropriate? When should it not be used? Is the marginal gain from having a more detailed model in fact worth its cost? In many cases the authors feel the above methodology is appropriate for quick, insightful analyses.

The second set of research questions relates to trade or other policy analysis using a multiple-commodity model. The authors feel that in this situation the multicommodity model is appropriate and in fact could build a case for expanding the model scope to nonagricultural and/or monetary sector activity. The appropriate questions then are: Under what conditions is single-commodity analysis appropriate? What are the relative strengths and weaknesses of a single- versus a multiple-commodity model? Finally, how do you know when to stop a model in terms of its scope? This question is important in a country such as Nicaragua, where time, skilled manpower, computer facilities, and quantitative expertise are potential major constraints.

A third set of research questions relates to the use of this model in a stability situation. The model basically assumes equilibrium. Stability analyses are done most frequently with dynamic disequilibrium models. The authors feel each has its place and believe the appropriate question is, when are the results of an equilibrium model appropriate for a stability examination (especially when the model may be put together rather simplistically)? Restrictive assumptions (as above) are certainly necessary.

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Effects of Exchange Rate Changes on U.S. Agriculture: A Dynamic Analysis

Robert G. Chambers and Richard E. Just

An econometric model of the wheat, corn, and soybean markets is used to examine the dynamic effects of exchange rate fluctuation on U S. commodity markets. Exports and agricultural prices are found to be sensitive to movements in the exchange rate, while domestic factors, such as disappearance and inventories, are less sensitive but still responsive. Dramatic short-run adjustments in prices and exports are followed by less dramatic but significant longer-run adjustments. Thus, the hypothesis of elastic response to the exchange rate seems particularly relevant for the short run.

Key words: agricultural prices, agricultural trade, exchange rate.

One of the most dramatic events in the international arena over the last decade was the devaluation of the dollar by almost 10% *vis-à-vis* special drawing rights (SDRs) in 1971. The devaluation was largely the result of an increasingly poor international payments situation for the United States. Dramatic as it was, however, the initial devaluation of the dollar was followed by yet another devaluation and eventual floating of the dollar in 1973. During this same period, the United States experienced the first in a series of deficits in the trade account. These facts, coupled with the still weak position of the dollar in international currency markets, have led many trade theoreticians and empiricists to question the overall effectiveness of devaluation as a policy tool. In fact, there is a school of thought (often identified as monetarist) which suggests that devaluation can have only monetary effects, in which case a devaluation likely causes portfolio adjustment but is unlikely to affect seriously the trade balance. Examples of theoretical research on this topic include the series of papers by Laffer (1969, 1976), while the paper by Miles presents some empirical evidence in support of the monetarist hypothesis.

On the other hand, a good deal of attention has been directed at the effect of these devaluations on the agricultural sector of the economy. If a devaluation strongly affects the agricultural sector, then the majority of the associated impact effect must come through an adjustment in the agricultural trade balance rather than through a portfolio adjustment. In an award-winning paper, Schuh has demonstrated (given implicitly nonmonetarist assumptions) that overvaluation and, hence, devaluation could have important effects on both the foreign component as well as the domestic component of the agricultural sector. This latter point is particularly relevant because many of the empirical studies of the effect of a devaluation on U.S. agriculture have concentrated on price and export effects. In a market where production occurs only once a year, however, any factor that impacts on both price and exports will, with little doubt, have important dynamic effects on domestic disappearance and inventory accumulation. One goal of the present study is to investigate the dynamics of these effects in an empirical model. Most of the modeling efforts that have been directed at this problem thus far, either econometric or judgmental, have been static in nature and are thus incapable of portraying the dynamic adjustment to a devaluation. This paper, on the other hand, seeks to identify the

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major dynamic characteristics of this adjustment process via dynamic multiplier analysis.

This paper is based on another paper by Chambers and Just which argues that past modeling efforts may have been overly restrictive in their specification of the exchange rate variable in empirical agricultural trade models. Specifically, many cross-price effects which are ignored in applied modeling because of problems of multicollinearity and degrees of freedom, collectively can cause a significant exchange rate effect which might be underestimated (overestimated) by only deflating own price by the exchange rate in an export equation. On the basis of the classic work by Orcutt on international price elasticities under a system of fixed or relatively fixed exchange rates, such as the crawling peg arrangements of Bretton Woods, economic agents also may respond differently to exchange rate adjustments than they do to market price movements. For both of these reasons, reduced-form exchange rate elasticities of price need not be restricted to lie between zero and −1, (0, −1). Because this proposition is clearly testable, some attention is directed at the associated empirical investigation. On balance, the reported statistical results tend to favor the proposition.

In this paper the authors attempt to develop a model which considers exchange rate adjustment as a monetary effect with adequate flexibility in specification, which reflects exchange rate effects on the domestic sector as well as the foreign sector of U.S. agriculture, and which appropriately considers the dynamics of the associated adjustment process. The model concentrates on the markets for the three most important U.S. agricultural exports—wheat, corn, and soybeans. In the following section, a dynamic econometric model of these three markets is presented and discussed. The model is then used to generate dynamic and long-run multipliers to investigate the time path of adjustment to fluctuations in the exchange rate and to a devaluation of the same size as the original devaluation of the Nixon era (in terms of the SDR-dollar rate). By and large, the results indicate that the devaluations of the early 1970s had extremely important effects on agricultural exports and prices as well as on domestic disappearance and inventory accumulation. Interestingly, however, the short-run effects are more dramatic that the long-run effects. The results also suggest that monetary factors in general, such as money supply controls, can have significant effects on agriculture through the exchange rate.

The Structural Model

The econometric model consists of fifteen equations, three of which are identities. These equations explain disappearance, inventories, exports, and production for three commodities—corn, wheat, and soybeans. The model is formulated in a seemingly recursive form with a separate block for each commodity. However, because of the likelihood of cross-block correlation of disturbances, the model is estimated as a single system by three-stage least squares (3SLS) using quarterly data for the period 1969(I)–77(II).

The results of the structural estimation with variable definitions and data sources are presented in table 1. Each functional relationship is assumed to be linear in parameters to simplify the estimation and subsequent dynamic analysis of the model, and each quarterly equation contains indicator variables to account for purely seasonal effects. Also, each equation is estimated in per capita form so as to preserve the linearity of the system and to allow the straightforward induction of a linear (in parameters) reduced-form from the structural estimates.[1] The model as a whole appears to fit well and achieve a sound level of statistical significance, as evidenced by the associated root-mean-squared errors (RMSE) and standard deviations for the estimated parameters (reported in parentheses). The signs of all coefficients appear to be reasonable in terms of a priori expectations.

The estimated model is substantially more aggregated than many models of agricultural markets although much less aggregated than those presented by Clark or Egbert. For example, it is not unusual to separate domestic disappearance of wheat into food disappearance and feed disappearance (e.g., Mo).

[1] This specification has a somewhat peculiar implication that the U.S. population elasticity of total exports is 1. However, population varies little during the sample period used here and is held constant for purposes of examining dynamic adjustments to exchange rate changes below. On the other hand, if exports are not considered in per capita terms while other demands are, then the system including identities becomes nonlinear. Thus, the dynamic analysis (which is the major focus of this paper) becomes messy and, in fact, cannot be performed generally without relying on approximations which may be poor, given the magnitude of changes considered.

Table 1. Structural Estimates

Disappearance equations

(1)
$$PWD = \underset{(.4111)}{-.6788} + \underset{(.1490)}{.002112}\, PWDL - \underset{\substack{(2.5337)\\ [-.087]}}{4.2093}\, RPW + \underset{\substack{(15.14)\\ [1.523]}}{44.93}\, RPDI + \underset{(.0620)}{.6863}\, SUM + \underset{(.0834)}{.2508}\, FALL + \underset{(.0505)}{.2555}\, WINT$$

$RMSE = .0979 \qquad PRMSE = .109$

(2)
$$PCD = \underset{(5.689)}{6.080} - \underset{(.1767)}{.1123}\, PCDL - \underset{\substack{(82.34)\\ [-.125]}}{42.95}\, RPC - \underset{\substack{(219.8)\\ [-1.553]}}{248.1}\, RPDI + \underset{\substack{(.1561)\\ [.506]}}{.1893}\, CATTLE + \underset{\substack{(.1394)\\ [.723]}}{.2240}\, HOG$$
$$+ \underset{\substack{(.04749)\\ [.267]}}{.03955}\, PCAT - \underset{(.545)}{1.046}\, SUM + \underset{(.7351)}{.7720}\, FALL + \underset{(.4655)}{.9841}\, WINT$$

$RMSE = .717 \qquad PRMSE = .148$

(3)
$$PSD = \underset{(.362)}{1.146} - \underset{(.08563)}{.06490}\, PSDL - \underset{\substack{(1.982)\\ [-.077]}}{2.273}\, RPS - \underset{\substack{(13.695)\\ [-.194]}}{6.227}\, RPDI + \underset{\substack{(.01491)\\ [.169]}}{.01272}\, CATTLE - \underset{(.0776)}{.4746}\, SUM + \underset{(.0902)}{.3009}\, FALL + \underset{(.0755)}{.1030}\, WINT$$

$RMSE = .146 \qquad PRMSE = .150$

Inventory equations

(4)
$$PWI = \underset{(.827)}{1.806} + \underset{(.1111)}{.5562}\, PWIL - \underset{\substack{(19.36)\\ [-.247]}}{76.17}\, RPW + \underset{(.304)}{6.559}\, SUM + \underset{(.546)}{1.535}\, FALL + \underset{(.3412)}{.7780}\, WINT$$

$RMSE = .489 \qquad PRMSE = .085$

(5)
$$PCI = \underset{(.929)}{1.025} + \underset{(.0422)}{.6901}\, PCIL - \underset{\substack{(28.9)\\ [-.172]}}{143.6}\, RPC + \underset{\substack{(.0376)\\ [.363]}}{.7221}\, PCPR - \underset{(.346)}{1.161}\, SUM + \underset{(.889)}{1.244}\, FALL + \underset{(.3772)}{.6038}\, WINT$$

$RMSE = .528 \qquad PRMSE = .045$

(6)
$$PSI = \underset{(.244)}{-1.153} + \underset{(.0492)}{.9153}\, PSIL - \underset{\substack{(3.398)\\ [-.033]}}{2.646}\, RPS + \underset{\substack{(.0674)\\ [.542]}}{.9752}\, PSPR + \underset{(.1229)}{.5451}\, SUM - \underset{(.4334)}{.7006}\, FALL - \underset{(.12286)}{.03227}\, WINT$$

$RMSE = .199 \qquad PRMSE = .076$

Export equations

(7)
$$PWX = \underset{(1.747)}{4.396} + \underset{(.1671)}{.2914}\, PWXL - \underset{\substack{(11.595)\\ [-.174]}}{9.498}\, RPW - \underset{\substack{(1.923)\\ [-2.045]}}{2.282}\, SDR - \underset{\substack{(.004627)\\ [-1.025]}}{.008416}\, THPW - \underset{\substack{(.010940)\\ [-.349]}}{.008831}\, WSTOCKW - \underset{\substack{(.006899)\\ [-.130]}}{.004221}\, PL480$$
$$+ \underset{(.1823)}{.2014}\, SUM + \underset{(.1325)}{.1764}\, FALL - \underset{(.126058)}{.003492}\, WINT$$

$RMSE = .223 \qquad PRMSE = .220$

$$\text{(8)}\quad PCX = \underset{(1.817)}{8.235} + \underset{(.1255)}{.2667}\,PCXL - \underset{\substack{(19.89)\\ [-.465]}}{40.53}\,RPC - \underset{\substack{(1.562)\\ [-5.227]}}{7.096}\,SDR - \underset{\substack{(.02669)\\ [-.554]}}{.06112}\,WSTOCKC + \underset{\substack{(6.091)\\ [.102]}}{3.817}\,RPS + \underset{(.3289)}{.9728}\,SUM + \underset{(.2142)}{.6726}\,FALL + \underset{(.1817)}{.3868}\,WINT$$

$RMSE = .249 \qquad PRMSE = .202$

$$\text{(9)}\quad PSX = \underset{(.549)}{1.197} + \underset{(.1422)}{.3005}\,PSXL - \underset{\substack{(3.058)\\ [-.202]}}{3.393}\,RPS - \underset{\substack{(.5015)\\ [-1.311]}}{.7972}\,SDR - \underset{\substack{(.020180)\\ [-.015]}}{.003572}\,NONUSS - \underset{(.0567)}{.1658}\,SUM + \underset{(.0661)}{.2854}\,FALL + \underset{(.05837)}{.01933}\,WINT$$

$RMSE = .105 \qquad PRMSE = .189$

Production equations

$$\text{(10)}\quad PWPR = \underset{\substack{(20.7)\\ [.498]}}{230.5}\,RWAP + \underset{\substack{(27.4)\\ [.487]}}{282.9}\,RWSP$$

$RMSE = .623 \qquad PRMSE = .323$

$$\text{(11)}\quad PCPR = \underset{\substack{(85)\\ [.555]}}{1066}\,RCAP + \underset{\substack{(108)\\ [.443]}}{1069}\,RCSP$$

$RMSE = 1.481 \qquad PRMSE = .250$

$$\text{(12)}\quad PSPR = \underset{\substack{(6.8)\\ [.641]}}{133.1}\,RSAP + \underset{\substack{(12.1)\\ [.358]}}{133.0}\,RSSP$$

$RMSE = .225 \qquad PRMSE = .154$

Identities

$$\text{(13)}\quad PWPR + PWIL = PWD + PWI + PWX$$
$$\text{(14)}\quad PCPR + PCIL = PCD + PCI + PCX$$
$$\text{(15)}\quad PSPR + PSIL = PSD + PSI + PSX$$

Sources: Commodity Research Bureau; Great Britain Commonwealth Secretariat; IMF; UN-FAO; USDA *Agricultural Statistics, Fats and Oils Situation, Feed Situation, Wheat Situation;* USDC *Business Statistics, Survey of Current Business.*

Note: Numbers in parentheses are standard errors; numbers in brackets are elasticities. Also, note that *RMSE* denotes root mean squared error and *PRMSE* is *RMSE* divided by the mean of the dependent variable. Variable definitions are as follows:

Jointly Dependent Variables

PWD—per capita wheat disappearance (bushels per person).
PCD—per capita corn disappearance (bushels per person).
PSD—per capita soybean disappearance (bushels per person).
PWI—per capita wheat inventories (bushels per person).
PCI—per capita corn inventories (bushels per person).
PSI—per capita soybean inventories (bushels per person).

Table 1. Continued

PWX—per capita wheat exports (bushels per person).
PCX—per capita corn exports (bushels per person).
PSX—per capita soybean exports (bushels per person).
RPW—wheat price (No. 2 SRW at Chicago) divided by wholesale price index.
RPC—corn price (No. 3 yellow at Chicago) divided by wholesale price index.
RPS—soybean price (No. 1 yellow at Chicago) divided by wholesale price index.
PWPR—per capita wheat production (bushels per person).
PCPR—per capita corn production (bushels per person).
PSPR—per capita soybean production (bushels per person).

Predetermined Variables

SDR—exchange rate (*SDR* per dollar).
RPDI—per capita disposable income divided by wholesale price index.
FALL,
WINT,
SUM—seasonal indicator variables.
CATTLE—number of cattle on feed (million head).
HOG—number of pigs on feed (million head).
PCAT—price of beef cattle, farm level (dollars per cwt.).
THPW—threshold price of wheat (units of account per metric ton).
WSTOCKW—stocks of wheat in other major exporters (metric tons).
PL480—P. L. 480 shipments of wheat (million bushels).
WSTOCKC—stocks of corn in other major exporters (metric tons).
NONUSS—non-U.S. exports of soybeans (metric tons).
RWAP—average price of wheat divided by wholesale price index.
RCAP—average price of corn divided by wholesale price index.
RSAP—average price of soybeans divided by wholesale price index.
RWSP—support price wheat divided by wholesale price index.
RCSP—support price corn divided by wholesale price index.
RSSP—support price soybeans divided by wholesale price index.

In the context of these definitions, *L* indicates a lagged variable, e.g., *PWDL* is lagged per capita demand for wheat.

Also, several empirical studies on U.S. grain exports—for instance, Fletcher, Just, and Schmitz; and Johnson, Grennes, and Thursby—differentiate U.S. exports by country of destination. Mo, for example, further chooses to partition inventories into government-held inventories and privately held inventories. The aggregate nature of the present study, however, is justified by the fact that interest is centered on the net effects of exchange rate fluctuation in each of the markets rather than on each particular component of the market.

Per capita wheat disappearance (*PWD*) is assumed to be a function of the own-price of wheat deflated by the wholesale price index (*RPW*), real per capita disposable income (*RPDI*), the lagged dependent variable, and quarterly indicator variables (*FALL*, *WINT*, *SUM*). The estimated coefficients for *RPW* and *RPDI* are both theoretically plausible and significant in a 5%, one-sided asymptotic sense. The coefficients of each of the indicator variables are all statistically significant, suggesting a strong seasonal effect. The estimated elasticities indicate a fairly inelastic response to the deflated price of wheat (−.087 at means), while wheat appears to be a superior good with an estimated elasticity of deflated income of approximately 1.5.

The per capita corn disappearance (*PCD*) and per capita soybean disappearance (*PSD*) equations are taken to be functions of the own-deflated prices (*RPC* and *RPS*, respectively), and the quarterly indicators. In addition, since corn finds relatively more use for feed, particularly for hogs, domestic corn demand is taken to be a function of the number of hogs on feed (*HOG*), and the price of cattle (*PCAT*), the latter of which reflects short-run adjustments in the livestock industry.[2] Arzac and Wilkinson (p. 301) report a positive income coefficient in their domestic corn demand equation, while the results in table 1 indicate a negative income elasticity for both *PCD* and *PSD*. It should be noted, however, that neither their reported coefficient nor the ones in table 1 are significantly different from zero, and thus, there appears to be little statistical reason to prefer one to the other. Furthermore, a negative income coefficient for a feed grain is not entirely implausible because derived demand due to meat consumption is reflected through the livestock variable. The numbers of cattle and hogs on feed appear to be important in the determination of per capita corn disappearance with elasticities of approximately .5 and .7, respectively. Like Arzac and Wilkinson, table 1 suggests a negative, but statistically insignificant, own-price elasticity for *PCD*.

The estimated inventory equations are based on the hypothesis that inventories are inversely related to own-price and are consistent with the partial adjustment inventory model suggested by Labys (pp. 70–71). Logically, as the own-price rises, the opportunity cost of carrying grain out of a given period rises and the incentives for profit taking increase. The converse is true as price falls. Per capita wheat inventories (*PWI*), thus, are taken to be a function of deflated price, the lagged dependent variable, and the quarterly indicator variables. Own-deflated price has the expected sign and is significant statistically. Per capita corn and soybean inventories (*PCI*, *PSI*) were both estimated as a linear function of own-deflated price, lagged production indicator, the lagged dependent variables, and the quarterly indicator variables. Both equations achieve a strong level of statistical significance. Also, with the exception of soybeans, inventories appear to be responsive to own-price movements although in an inelastic sense. Respective price elasticities are −.247, −.172, and −.033.

As mentioned earlier, the export equations represent somewhat of a departure from traditional modeling of grain exports in their treatment of the exchange rate variable (for alternative specifications see, for example, Johnson, Grennes, and Thursby; Greenshields). The theoretical basis for this specification has been developed in Chambers and Just, and one purpose of the present study is to investigate empirically the validity of the associated argument. Although Chambers and Just argue for including "indices for 'all other' traded commodities and all nontraded commodities" while weighting "the 'all other' commodity index by the exchange rate" (p. 255), the present study follows the simpler alternative of including the *SDR* term as a separate regressor. This is done because the necessary indices are not available and be-

[2] The reader may note that a number of other variables also were considered in explaining domestic disappearance. For example, because soymeal is an important ingredient in some poultry feeds, poultry numbers were considered in the soybean equation but no plausible coefficient could be obtained suggesting that poultry feed demand is not one of the major determinants of domestic soybean demand.

cause deflating own-price and the commodity index by the exchange rate introduces a significant nonlinearity into the system, making multiplier analysis extremely difficult. The own-price term, however, is deflated by the wholesale price index which places a relatively heavy weight on traded commodities while not ignoring nontraded commodities; thus, cross-price effects of nontraded commodities should be depicted adequately.

Also, one might note that exports to centrally planned economies are considered endogenous to the model specified and estimated here. Some previous studies have treated such exports as exogenous in estimating U.S. export demand. To do so, however, denies that central planning bodies possess economic rationality. Internal prices may be meaningless in a centrally planned economy, but certainly external prices can be important. For example, there is no reason to assume that the Soviet Union might not import a little less grain if the price they must pay is very high rather than very low. While such trade may be interrupted occasionally by political factors such as with the recent Russian grain embargo, there is no reason to rule out rational economic responses on the part of both countries when such political barriers are not effective (as they generally were not during the relevant sample period). In fact, the results of Fletcher, Just, and Schmitz, in which exports to the Soviet Union are investigated in a separate equation, verify that this particular centrally planned economy responds significantly to external price incentives.

If centrally planned economies possibly respond to external price incentives, however, then the associated exports are endogenous in grain trade models and any attempt to treat them as exogenous variables generally will lead to biased and inconsistent estimates. Thus, exports to centrally planned economies, as well as other commercial exports, are necessarily considered as endogenous variables which respond to the usual set of external or international economic variables.

With this in mind, per capita wheat exports (*PWX*) are presumed to be a linear function of own-deflated wheat price (denominated in domestic currency units), the exchange rate (*SDR*), the European Community's threshold price (*THPW*) for wheat imports, the stocks of wheat in other major exporting countries (*WSTOCKW*), P.L. 480 shipments of wheat (*PL480*), the lagged dependent variable, and the indicator variables. Per capita corn exports (*PCX*) are represented as a linear function of own-deflated price, the exchange rate, stocks of corn in the other major exporting nations (*WSTOCKC*), the price of soybeans (to represent relevant substitution possibilities), the lagged dependent variable, and the indicator variables. Finally, per capita soybean exports (*PSX*) were taken to be a function of own-deflated price, the exchange rate, non-United States exports (*NONUSS*) of soybeans, the lagged dependent variable, and the seasonal indicators.[3]

The exchange rate variable is highly significant in the corn export equation and significant at a 6% or 7% level in the soybean export equation (asymptotically). While the significance is less in the wheat export equation, other variables also are less significant presumably due to the large number of other explanatory forces considered. For example, by eliminating *WSTOCKW* from the equation (which has a t-ratio of only $-.81$), the *SDR* t-ratio more than doubles to -2.54, while the coefficient increases by only about 30%. The wide range of alternative explanatory variables is retained in the equation to give other forces the maximum opportunity of explaining the endogenous variables which are so highly correlated with exchange rates.

These results coupled with the earlier findings of Fletcher, Just, and Schmitz, and Meilke and de Gorter provide strong empirical evidence supporting the exchange rate specification used in those papers as well as in the present study. Furthermore, the estimated structural exchange rate elasticities for exports (all larger than unity) indicate that the level of U.S. grain exports has been very sensitive to fluctuation in the exchange rate. Hence, the arguments of Schuh and others appear to be valid, and there seems to be evidence that devaluations and depreciations can lead to significant real adjustments in the agricultural trade balance as well as the portfolio

[3] Attempts also were made to incorporate other indicators of the international demand and supply situation such as the level of freight rates and the threshold price of corn. However, apparent problems of multicollinearity with other included regressors led to poor statistical results. Shipments of corn under P.L. 480 were not included because they have amounted to less than 1% of U.S. corn exports. One might also note that while the *SDR*-exchange rate depends perhaps too heavily on developed country exchange rates for general agricultural trade modeling, it is highly correlated with many of the less developed country exchange rates in this sample period because of the dramatic nature of the U.S. devaluations. Thus, its use seems adequate for present purposes, particularly in view of the cost of constructing an alternative basket rate.

adjustment emphasized by monetarists. On the other hand, the estimated price elasticities for exports range from .17 to .46 which, following the arguments of Chambers and Just, indicates a significant differential effect between exchange rate and own-price movements. This differential may be attributed, among other things, to cross-price demand and supply effects reflected through the exchange rate and a differential response rate on the part of economic agents to exchange rate and price movements. The overall, dynamic impact of the exchange rate on these three markets will be investigated in greater detail below.

Modeling production in a quarterly, simultaneous equation system presents an interesting problem since production usually occurs only once a year. (For an exception to this treatment see Bradford and Kelejian.) The overall production model used in the estimation follows from the work of Cromarty and Houck and Ryan. Production is expressed as a function of the deflated support price (*RWSP, RCSP, RSSP*) and the deflated lagged average price (*RWAP, RCAP, RSAP*) received by the farmer. To handle the periodicity problem, both sides of the production equation are multiplied by an indicator variable taking the value 1 in the period when the bulk of production occurs and zero otherwise. This allows the application of system estimation. Each of the estimated equations appears to be significant. However, because of the specification one must bear in mind that the reported standard errors are misleading in a downward direction.

The Reduced-Form Model

The 3SLS derived, reduced-form estimates for the model are reported in table 2 (elasticities are reported in brackets). Because the model appears to be recursive in nature, the reduced form also was estimated by Zellner's seemingly unrelated regression technique. However, because of the similarity of the results, only the derived 3SLS estimates are reported. The coefficients of the reduced form (impact multipliers) are interesting because they present a more accurate picture of the total effects of predetermined variables than simple elasticities computed from the structural form. In particular, the reduced form provides equations for the jointly dependent prices (*RPW, RPC, RPS*) while also recognizing the effect that the exchange rate has on per capita disappearance and inventories of the three commodities. The reduced form is also used to generate the dynamic multipliers associated with the exogenous variables. Before proceeding to the investigation of the dynamic properties of the model, a closer look at the impact elasticities associated with the exchange rate is worthwhile.

One of the main contentions of the paper by Chambers and Just is that restriction of the exchange rate elasticity of price to the closed interval (0, −1) may be incorrect.[4] The results in table 2 clearly support this proposition since none of the impact elasticities are within the unit interval. The impact effect of a change in the exchange rate on deflated grain prices is thus apparently substantial. To gauge the size of this effect, note that the deflated price of wheat was .01531 in the first quarter of 1971 and .02248 in the first quarter of 1975. In the intervening period the *SDR*/$ rate had fallen from 1 to .8040, so about 70% of the increase in the deflated wheat price can be explained by short-run adjustments to the exchange rate. In dollars and cents, the impact effect of such a change is about $1.73 per bushel, whereas the actual price rose by about $2.10. For the same period, all of the increases in corn- and soybean-deflated prices can be explained by the dollar depreciation.

A similar analysis can be performed for the level of wheat, corn, and soybean exports with the result that the depreciation of the exchange rate over that period is capable of explaining all of the increase in wheat and soybean exports and over 90% of the increase in corn exports. Although the preceding experiment may overstate the exchange rate effect somewhat, it serves to demonstrate the significant effect that exchange rate fluctuations can have in moving from a period of fixed exchange rates to a period of fluctuating rates.

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[4] One might note that under some stringent assumptions, theory implies that the exchange rate elasticity must lie in the interval (0, −1). For example, theorems 4.D.1 and 4.D.3 of Takayama (p. 392–3) imply that if all goods are net gross substitutes and all income elasticities are positive, then this must be the case. However, the estimated system structure in table 1 obviously admits the possibility of negative income elasticities (see the corn and soybean disappearance equation where income serves as a determinant of direct-human or, at least, nonlivestock consumption). Thus, such a restriction is inappropriate. Moreover, even theorems of this type cannot be applied in restricting the exchange rate elasticity if phenomena such as the Orcutt hypothesis are operative. The latter point is particularly relevant since exchange rates were under direct control for a large part of the sample period under investigation here.

Table 2. Reduced-Form Equations

Disappearance equations

(1) $PWD = -.9374 + \underset{[.002]}{.002014}\,PWDL + \underset{[.134]}{.02078}\,PWIL - \underset{[-.015]}{.01365}\,PWXL + \underset{[.108]}{.1068}\,SDR + \underset{[1.451]}{42.82}\,RPDI + \underset{[.050]}{10.80}\,RWAP + \underset{[.054]}{.0003941}\,THPW$

$+ \underset{[.019]}{.0004136}\,WSTOCKW + \underset{[.007]}{.0001977}\,PL480 + .3376\,SUM + .1589\,FALL + .2073\,WINT + \underset{[.049]}{13.25}\,RWSP$

(2) $PCD = 3.282 - \underset{[-.093]}{.09108}\,PCDL - \underset{[-.001]}{.005637}\,PSDL + \underset{[.146]}{.05861}\,PCIL - \underset{[-.004]}{.007357}\,PSIL - \underset{[-.013]}{.05045}\,PCXL + \underset{[.003]}{.02610}\,PSXL$

$+ \underset{[.239]}{1.273}\,SDR - \underset{[-1.263]}{201.7}\,RPDI + \underset{[.036]}{56.06}\,RCAP - \underset{[-.001]}{.2867}\,RSAP + \underset{[.216]}{.03207}\,PCAT + \underset{[.027]}{.01156}\,WSTOCKC + \underset{[.413]}{.1546}\,CATTLE$

$+ \underset{[.586]}{.1816}\,HOG - \underset{[-.0001]}{.0003103}\,NONUSS - .8214\,SUM + .2536\,FALL + .6184\,WINT + \underset{[.029]}{56.21}\,RCSP - \underset{[-.0002]}{.2864}\,RSSP$

(3) $PSD = .8211 - \underset{[-.048]}{.04716}\,PSDL + \underset{[.065]}{.02316}\,PSIL - \underset{[-.047]}{.08219}\,PSXL + \underset{[.203]}{.2180}\,SDR - \underset{[-.141]}{4.524}\,RPDI + \underset{[.007]}{.9026}\,RSAP$

$+ \underset{[.123]}{.009244}\,CATTLE + \underset{[.002]}{.0009769}\,NONUSS - .4485\,SUM + .3321\,FALL + .07840\,WINT + \underset{[.004]}{.9018}\,RSSP$

Inventory equations

(4) $PWI = -2.875 - \underset{[-.0002]}{.001790}\,PWDL + \underset{[.940]}{.9323}\,PWIL - \underset{[-.044]}{.2469}\,PWXL + \underset{[.307]}{1.934}\,SDR - \underset{[-.202]}{38.08}\,RPDI + \underset{[.142]}{195.4}\,RWAP$

$+ \underset{[.134]}{.007132}\,THPW + \underset{[.052]}{.007485}\,WSTOCKW + \underset{[.020]}{.003577}\,PL480 + .3480\,SUM \quad .1280\,FALL - .09492\,WINT$

$+ \underset{[.139]}{239.8}\,RWSP$

(5) $PCI = -8.330 + \underset{[.030]}{.07104}\,PCDL - \underset{[-.002]}{.01885}\,PSDL + \underset{[.909]}{.8861}\,PCIL - \underset{[-.006]}{.02460}\,PSIL - \underset{[-.017]}{.1687}\,PCXL + \underset{[.004]}{.08728}\,PSXL$

$+ \underset{[.328]}{4.256}\,SDR + \underset{[.399]}{155.1}\,RPDI + \underset{[.251]}{957.6}\,RCAP - \underset{[-.0006]}{.9585}\,RSAP - \underset{[-.069]}{.02501}\,PCAT - \underset{[.037]}{.03865}\,WSTOCKC - \underset{[-.127]}{.1160}\,CATTLE$

$- \underset{[-.188]}{.1416}\,HOG - \underset{[-.0002]}{.001037}\,NONUSS - .4077\,SUM - .4895\,FALL - .6188\,WINT + \underset{[.200]}{960.2}\,RCSP - \underset{[-.0003]}{.9576}\,RSSP$

(6) $PSI = -1.532 + \underset{[.008]}{.02066}\,PSDL + \underset{[.976]}{.9423}\,PSIL - \underset{[-.020]}{.09568}\,PSXL + \underset{[.088]}{.2538}\,SDR + \underset{[.023]}{1.982}\,RPDI + \underset{[.350]}{130.8}\,RSAP$

$- \underset{[-.020]}{.004050}\,CATTLE + \underset{[.001]}{.001137}\,NONUSS + .5754\,SUM - .6642\,FALL - .06095\,WINT + \underset{[.196]}{130.7}\,RSSP$

Export equations

(7) $PWX = 3.812 - \underset{[-.0002]}{.000223}\,PWDL + \underset{[.267]}{.04690}\,PWIL + \underset{[.261]}{.2606}\,PWXL - \underset{[-1.829]}{2.041}\,SDR - \underset{[-.142]}{4.748}\,RPDI + \underset{[.100]}{24.36}\,RWAP$

$$-\underset{[-.916]}{.007526\,THPW}-\underset{[-.313]}{.007898\,WSTOCKW}-\underset{[-.117]}{.003775\,PL480}-.5855\,SUM-.03090\,FALL-.1123\,WINT$$
$$+\underset{[.098]}{29.90\,RWSP}$$

(8) $$PCX=5.048+\underset{[.080]}{.02005\,PCDL}+\underset{[.020]}{.02448\,PSDL}+\underset{[.543]}{.05530\,PCIL}+\underset{[.071]}{.03195\,PSIL}+\underset{[.216]}{.2191\,PCXL}-\underset{[-.051]}{.1134\,PSXL}$$
$$-\underset{[-4.072]}{5.529\,SDR}+\underset{[1.147]}{46.63\,RPDI}+\underset{[.132]}{52.90\,RCAP}+\underset{[.007]}{1.245\,RSAP}-\underset{[-.187]}{.007058\,PCAT}-\underset{[-.455]}{.05021\,WSTOCKC}-\underset{[-.405]}{.03858\,CATTLE}$$
$$-\underset{[-.507]}{.03998\,HOG}+\underset{[.002]}{.001348\,NONUSS}+1.229\,SUM+.2359\,FALL+.0003841\,WINT+\underset{[.106]}{53.04\,RCSP}+\underset{[.004]}{1.244\,RSSP}$$

(9) $$PSX=.7112+\underset{[.047]}{.02649\,PSDL}+\underset{[.170]}{.03457\,PSIL}+\underset{[.177]}{.1779\,PSXL}-\underset{[-.776]}{.4718\,SDR}+\underset{[.139]}{2.542\,RPDI}+\underset{[.017]}{1.347\,RSAP}$$
$$-\underset{[-.122]}{.005194\,CATTLE}-\underset{[-.009]}{.002114\,NONUSS}-.1269\,SUM+.3320\,FALL-.01745\,WINT+\underset{[.010]}{1.346\,RSSP}$$

Production equations

(10) $$PWPR=\underset{[.498]}{230.5\,RWAP}+\underset{[.487]}{282.9\,RWSP}$$

(11) $$PCPR=\underset{[.555]}{1066\,RCAP}+\underset{[.443]}{1069\,RCSP}$$

(12) $$PSPR=\underset{[.641]}{133.1\,RSAP}+\underset{[.358]}{133.0\,RSSP}$$

Price equations

(13) $$RPW=.06145+\underset{[.001]}{.00002351\,PWDL}-\underset{[-1.535]}{.004938\,PWIL}+\underset{[.177]}{.003242\,PWXL}-\underset{[-1.243]}{.02539\,SDR}+\underset{[.817]}{.4999\,RPDI}-\underset{[-.575]}{2.565\,RWAP}$$
$$-\underset{[-.623]}{.00009363\,THPW}-\underset{[-.212]}{.00009826\,WSTOCKW}-\underset{[-.079]}{.00004696\,PL480}+.08286\,SUM+.02183\,FALL$$
$$+.01146\,WINT-\underset{[-.563]}{3.148\,RWSP}$$

(14) $$RPC=.06514-\underset{[-.173]}{.0004947\,PCDL}+\underset{[.009]}{.0001312\,PSDL}-\underset{[-1.168]}{.001364\,PCIL}+\underset{[.033]}{.0001713\,PSIL}+\underset{[.101]}{.001175\,PCXL}$$
$$-\underset{[-.024]}{.0006077\,PSXL}-\underset{[-1.903]}{.02964\,SDR}-\underset{[-2.316]}{1.080\,RPDI}-\underset{[-.285]}{1.305\,RCAP}+\underset{[.003]}{.006674\,RSAP}+\underset{[.403]}{.0001742\,PCAT}$$
$$-\underset{[-.213]}{.0002691\,WSTOCKC}+\underset{[.739]}{.0008077\,CATTLE}+\underset{[1.091]}{.0009864\,HOG}+\underset{[.001]}{.000007224\,NONUSS}-.005242\,SUM$$
$$+.01207\,FALL+.008514\,WINT-\underset{[-.227]}{1.309\,RCSP}+\underset{[.002]}{.006683\,RSSP}$$

(15) $$RPS=.1431-\underset{[-.233]}{.007808\,SDL}-\underset{[-.841]}{.01019\,PSIL}+\underset{[.605]}{.03616\,PSXL}-\underset{[-2.643]}{.09590\,SDR}-\underset{[-.689]}{.7491\,RPDI}-\underset{[-.085]}{.3971\,RSAP}$$
$$+\underset{[.601]}{.001531\,CATTLE}-\underset{[-.031]}{.0004298\,NONUSS}-.01145\,SUM-.01375\,FALL+.01084\,WINT-\underset{[-.047]}{.3967\,RSSP}$$

Note: Elasticities are reported in brackets.

Turning to the effect of the exchange rate on the other variables in the system, note first of all that the impact effect on production is nil because of the recursive nature of the production equations. However, the exchange rate does impact on the other jointly dependent variables in the system as evidenced by table 2. In particular, *PWI*, and *PCI* seem to be responsive to changes in the exchange rate. This result is interesting because it suggests that the wheat and corn markets react to rapid increases in the level of their exports by drawing relatively more on inventories while the soybean market appears to curtail domestic consumption relatively more.

As well as providing estimates of the effect of the exchange rate on the jointly dependent variables of the system, the reduced form also allows analysis of the effects of other exogenous variables on the system. For example, it appears that the prices of corn and soybeans are fairly sensitive to fluctuations in the number of cattle placed on farms with elasticities of .74 and .60, respectively, while wheat price is fairly responsive to the level of the threshold price in the European Community, with an elasticity of −.62. This latter result is supportive of the model used by Johnson, Grennes, and Thursby. Corn price is particularly sensitive to hog numbers, with an elasticity of 1.09, and is somewhat responsive to short-run livestock market adjustments, with an elasticity of .40 with respect to cattle price.

Dynamic Characteristics of the Model

To investigate the dynamic nature of the model, it can be written (following Chow) as a matrix difference equation. Before examining the dynamic multipliers, one may be interested in the stability of the model, i.e., the eigenvalues which determine the expected time path of the jointly dependent variables (see Chow or Dhrymes).[5] The model is, indeed, stable, having as a dominant root a real, negative eigenvalue with modulus .8804. Although less than one, the size of this eigenvalue suggests that exogenous shocks to the model will have effects that persist for quite some time. In addition to the dominant eigenvalue, there are six other eigenvalues with negative signs, two of which are also quite large; thus, one can expect rather lengthy adjustment processes following exogenous shocks.

Table 3 reports the dynamic (interim) multipliers associated with the exchange rate for lag periods of one to twelve quarters. These multipliers represent a fairly long and smooth adjustment process once the initial shocks are over. The impact multipliers (reduced form coefficients) associated with the exchange rate indicate strong upward pressure on exports and price as an impact effect of a depreciation. The strong upward push on price leads to a slackening of domestic disappearance and inventory accumulation which in turn tends to reduce the rate of price increase originally caused by the depreciating exchange rate. Nevertheless, prices continue to rise as the tendency to satisfy deferred demand increases and, in the second or third quarter, rising prices begin to choke off and reverse the growth in exports. As time wears on, the effects diminish as the system approaches a new equilibrium point. But as the size of the dominant root would suggest, there are still noticeable effects for all of the jointly dependent variables, even in the twelfth period following devaluation.

Dynamic Effects of the First Nixon Devaluation

At the end of 1971, President Nixon announced an approximate 10% devaluation of the dollar (.0789 *SDR*/\$). Because of the considerable controversy in the literature about the effect of this devaluation on agricultural markets, consider a closer empirical examination of the issue in the context of the dynamic model of this paper. To this end, the impact, cumulative, and long-run (equilibrium) multipliers are computed to determine the (*a*) short-run impact effect of such a change in the exchange rate, (*b*) the maximum cumulative effect, and (*c*) the long-run adjustment to such a devaluation. These results are presented in table 4, where numbers in parentheses indicate the lag period.

As suggested by the reduced form, the impact effect of a 10% depreciation of the exchange rate is substantial. Corn exports rise by over 90 million bushels, wheat exports by about 24 million bushels, and soybean exports

[5] Most general proofs of multimarket stability rely on assumptions of net gross substitutability or positive income elasticities for all goods (see, e.g., Takayama, p. 399–406). Because the estimated model in table 2 contains some negative income elasticities, an *ex post* examination of stability of the model is crucial before proceeding with further analysis.

Table 3. Dynamic Multipliers for a Unit Change in the SDR Per Dollar Rate

Variable	Time Horizon in Quarters											
	1	2	3	4	5	6	7	8	9	10	11	12
PWD	.1068	.06826	.05410	.04716	.04249	.03868	.03533	.03229	.02953	.02701	.02470	.02259
PCD	1.273	.3970	.2823	.2232	.1905	.1652	.1439	.1256	.1095	.90550	.08326	.07256
PSD	.2180	.03437	.0108	.00608	.00502	.00459	.00429	.00402	.00378	.00354	.00332	.00312
PWI	1.934	2.307	2.259	2.108	1.940	1.777	1.626	1.488	1.361	1.244	1.138	1.041
PCI	4.256	4.743	4.366	3.865	3.389	2.963	2.588	2.260	1.973	1.722	1.503	1.311
PSI	.2538	.2888	.2794	.2637	.2477	.2324	.2181	.2046	.1920	.1801	.1690	.1585
PWX	−2.041	−.4411	−.006784	.1042	.1260	.1238	.1156	.1064	.09748	.08920	.08160	.07463
PCX	−5.529	−.8837	.09452	.2772	.2865	.2608	.2306	.2025	.1774	.1554	.1361	.1192
PSX	−.4718	−.06936	.00144	.00969	.01100	.01065	.01005	.00944	.00886	.00831	.00780	.00732
RPW	−.02539	−.01616	−.01282	−.01118	−.01007	−.00917	−.00837	−.00765	−.00700	−.00640	−.00585	−.00535
RPC	−.02964	−.01257	−.00761	−.00594	−.00502	−.00434	−.00378	−.00330	−.00288	−.00251	−.00219	−.00191
RPS	−.09590	−.02134	−.00572	−.00298	−.00238	−.00216	−.00202	−.00189	−.00177	−.00167	−.00156	−.00147

about 8 million bushels. To compensate for this dramatic upsurge in exports in the short run, domestic demand is curtailed. Hence, wheat disappearance falls by 1.7 million bushels, with the bulk of the adjustment coming through a rapid curtailment of wheat inventories. Also, in the corn market, a substantial amount of the increase in exports is accommodated by a disaccumulation of inventories, while in the soybean market the response is more balanced, with disappearance curtailment accounting for approximately 46% of the export rise and inventory adjustment accounting for the other 54%. The sharp upward pressure on overall demand which is not met immediately by a corresponding increase in total availability, of course, leads to a dramatic increase in prices. In such a situation, where supply is highly inelastic, an equal percentage increase in price is not surprising, and, following the arguments of Chambers and Just, suggests perhaps a more than elastic response. Such appears to be the case in table 4, where all the short-run exchange rate elasticities of prices are larger than unity (negatively). Thus, the impact effect of a devaluation is dramatic.

However, such a dramatic increase in prices leads to increased production in later periods, while further eroding the demand for exports as much of the relative price advantage gained by the devaluation is lost to subsequent inflation of domestic prices—a classic problem associated with devaluation policies. The long-run and cumulative effects reported in table 4 support this argument. The peak effects on exports are reached relatively soon after the devaluation. As inflationary tendencies take over, the system tends to cycle toward the steady-state solution and the effects start to wear off. The approximate 10% devaluation is associated with a maximum decrease of wheat disappearance of about 1 million bushels, corn disappearance decreases by about 17 million bushels, and soybean disappearance falls by about 3 million bushels. In all three markets, the bulk of the response can be attributed to inventory disaccumulation. Inventories tend to be sufficient to weather the devaluation (with substantial price increases) because exports peak and begin to fall rather soon after only two or three quarters. The effect on prices seems to dampen rather quickly as a result.

Perhaps the most important questions when investigating changes in exogenous variables

Table 4. Effect of a 10% Devaluation on the U.S. Agricultural Sector

Variable	Impact Effect	Short-Run Elasticity	Largest Effect of Sustained Devaluation	Long-Run Effect of Sustained Devaluation	Long-Run Elasticity
	(Million bushels)				
Wheat disappearance	− 1.767	.108	− 1.12 (∞)	−1.12	.069
Corn disappearance	−21.048	.239	− 7.15 (∞)	−17.15	.194
Soybean disappearance	− 3.605	.203	− 3.16 (∞)	−3.16	.178
Wheat inventories	−31.976	.307	− 3.07 (∞)	−13.07	.125
Corn inventories	−70.371	.328	−30.11 (∞)	−30.11	.140
Soybean inventories	− 4.196	.088	− 1.79 (∞)	−1.79	.038
Wheat exports	33.743	−1.829	41.15 (3)	27.25	−1.477
Corn exports	91.420	−4.072	106.03 (2)	77.37	−3.447
Soybean exports	7.801	−.776	8.97 (3)	6.75	−.671
	($ per bushel)				
Wheat price	.284	−1.242	.181 (∞)	.181	−.790
Corn price	.332	−1.903	.240 (∞)	.240	−1.377
Soybean price	1.073	−2.643	.879 (∞)	.879	−2.165

Note: All figures correspond to the means of data in the sample period. Numbers in parentheses indicate the time horizon in quarters corresponding to the largest effect of sustained devaluation.

relate to the total or long-run effects of such a change after a new equilibrium has been reached. These results are represented by columns (3) and (4) in table 4. Here, the long-run elasticities are particularly important. A 10% devaluation calls forth about a 0.7% long-run change in wheat disappearance and about a 2% change in corn and soybean disappearance. Wheat inventories, on the other hand, fall by about 1.2%, corn inventories by about 1.4% and soybean inventories by less than 0.5%. In percentage terms, therefore, the domestic response in the corn market is much more balanced than in the wheat and corn markets. In the long run, wheat market adjustments tend to entail inventory responses, while soybean market adjustments tend to involve consumption responses.

On the other hand, a sustained devaluation signals dramatic long-run changes in the level of grain exports. Wheat exports eventually respond to a 10% devaluation with a 15% rise, corn exports with a 35% rise, and soybean exports with a 7% rise. The response of domestic price levels to a sustained depreciation is also interesting. Only wheat price responds in an inelastic manner over the long run, while both corn and soybean prices appear to be elastic. Hence, there is further empirical support for the proposition of possible elastic response to exchange rates. Interestingly, the estimated long-run domestic wheat price elasticity implied by the present study is markedly similar to that suggested by the work of Johnson, Grennes, and Thursby. Their results suggest that the effect of a 10% devaluation on domestic wheat price would be about 6.9%, while the result here is approximately 7.9%. Nevertheless, the results here suggest a quite elastic short-term impact on domestic prices; thus, important income, welfare, and allocational effects could be realized as the result of such a devaluation, which might be ignored in a more long-run type of model. Since the Johnson, Grennes, and Thursby model is apparently static, its inherent structure is not designed for and, hence, cannot capture the short-run effects investigated here.

Conclusions and Implications

This paper presents a dynamic, quarterly, econometric model of the U.S. wheat, corn, and soybean markets designed to investigate exchange rate specification and the dynamic effects of exchange rate fluctuations on the domestic and foreign sectors of these three markets. The results indicate that exchange rate fluctuation has had a significant real impact on agricultural markets by altering the volume of exports and the relative split between exports and domestic use of the three commodities. Hence, the results suggested by Miles and Laffer do not appear to be generally true for agricultural markets. Although the estimated model is stable, some interesting cy-

clical forces are clearly operative. The dynamic and long-run adjustment of prices and exports to changes in the exchange rate is particularly interesting. In this context, there appears to be empirical support for the major hypotheses of the Chambers-Just paper, while the results presented are not inconsistent with the results of previous modeling efforts such as that presented by Johnson, Grennes, and Thursby. For example, for wheat the short-run exchange rate elasticity of price is well above 1.00 as suggested by Chambers and Just, while the long-run elasticity of .79 is well below 1.00, as obtained in the static model of Johnson, Grennes, and Thursby. In the case of corn and soybeans, however, both short- and long-run exchange rate elasticities of price are well above 1.00.

A second purpose of this study has been to study the dynamic influence of the exchange rate on the agricultural economy. The results suggest a rather complex and long-term adjustment. Disappearance, inventories, and exports adjust somewhat differently among crops. For example, the soybean domestic demand responds quickly to a devaluation while wheat demand responds very slowly. Similarly, soybean price tends to adjust more quickly, while wheat price adjusts more slowly. For all markets, however, exports increase rapidly and then decline somewhat after several quarters. The continued higher level of exports is then sustained partially by a long-term declining trend in inventories. Comparing among crops, price elasticities of supply and demand apparently explain why soybeans respond to devaluation with a relatively large price increase and smaller export growth, while corn and wheat respond with relatively smaller price increases but larger export impacts.

Because the exchange rate is essentially a monetary variable, these results have other important implications for the agricultural sector. For example, an important implication of this research is that policy tools, such as open market operations, which are usually viewed as having little or no effect on agricultural markets can have significant impacts via the exchange rate. Similarly, fluctuation in other monetary variables also can have important effects on U.S. agriculture.

The results further imply that the devaluations and subsequent floating of the dollar may have had important allocational effects within the U.S. economy. If, as is generally supposed, the devaluation did little to enhance the overall balance of trade situation in the United States, there is no doubt that an increased share in export earnings has accrued to the agricultural sector. Another factor which must be considered with respect to the rest of the economy is that the period of study coincides almost exactly with the appearance of the Organization of Petroleum Exporting Countries (OPEC) cartel and the subsequent quantum jump in energy costs to agriculture and other sectors of the economy. Perhaps the coincidence of this development is responsible for the lack of response of overall U.S. trade balances to devaluation. The significant impacts observed in agricultural exports, however, suggest that the devaluation was, after all, quite effective. For example, one might consider just how much worse the balance of trade situation would have been in view of the OPEC development without the counterbalancing effects of a devaluation on agricultural trade.

If the estimates in this study are a reasonable interpretation of the data, it appears that general trade conditions of the United States have an important influence on the agricultural economy that may not be realized for some time after the relevant policy decisions or terms-of-trade observations. More important, the contrasting response of different crops to general trade and policy developments suggests the importance of tailoring any counterbalancing policies (which may be designed to aid adjustments) to the individual sectors of the agricultural economy with which they are intended to deal.

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Major Determinants of Ocean Freight Rates for Grains: An Econometric Analysis

James K. Binkley and Bruce Harrer

Econometric analysis of ocean grain rates suggests that ship size and trade volume are of approximately equal importance with distance in determining rates. Use of large ships reduces at-sea costs and hence the role of distance; but larger ships appear to incur higher port costs, which suggests that efficient port facilities are required for scale economies to be realized. Policies to improve shipping technology and increase trade volume can lead to lower rates, reduce geographic differences among exporters, and thus lead to more competitive markets. This implies that the role of transportation in trade analysis should not be ignored.

Key words: freight rates, grain transportation, international trade, ocean shipping, ports.

International trade in bulk agricultural commodities recently has become more important to the world economy. Yet economists have devoted little attention to international shipping. Transport costs between countries can pose a formidable barrier to trade, similar in effect to tariffs and institutional constraints. Sampson and Yeats found transport costs to be a more significant trade barrier for United Kingdom exports than tariffs; Finger and Yeats come to similar conclusions for U.S. imports.

In addition, ocean transportation changes can affect the domestic grain transport system of major exporters, such as the United States and Canada. Jones argues that many studies have examined the efficiency of domestic grain transportation systems, but little has been done internationally. Transport costs are thought to reflect unalterable geographic factors—primarily distance between traders—and, hence, are not policy relevant. Geraci and Prewo and Finger and Yeats have criticized this viewpoint. Many factors can influence rates, and rates need not be directly proportional to distance. For example, rates on grain from the U.S. East Coast to Rotterdam are about 10% higher than corresponding rates from the U.S. Gulf Coast, even though the distance is significantly less. A further problem is that accurate information on ocean freight rates and/or costs is difficult to obtain (Geraci and Prewo). But without analysis of ocean transport costs, it is difficult to formulate intelligent trade policy, since the effects of tariffs and quotas can be confounded with those due to transportation. This lack also may seriously compromise research in international trade, for differences in transport costs can be one of the primary sources of comparative trading advantages among exporters.

This study empirically examines the major factors accounting for cross-sectional differences in ocean freight rates for grains. The emphasis is on factors causing relative rate differences and not on the level of rates. The analysis separates the effect of at-sea costs and port costs on rate differences, and estimates the effects of major port areas on rates. Thus, the role of unalterable versus controllable factors in determining comparative port advantage is examined.

In the next section, the rationale for the approach, hypotheses, and models used in the analysis is developed. The data are described, followed by the estimation results. In the next section, the authors address the role of port areas and factors that give shipping advan-

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tages to some ports. Finally come the conclusions of the study.

Model Formulation

Most ocean grain trade moves in general purpose tramp ships or specialized bulk carriers. Tramp ships travel no regularly scheduled routes, generally being chartered on a single-voyage basis. Specialized bulk carriers are more regular in their routes traveled and often carry grain as a return load for voyages involving coal, cars, or other cargo. The market is divided between shipper-owned and/or time-chartered vessels and single-voyage charters. It is the latter that are of interest here, because voyage rates are determined and reported in this market. Rates are set by shippers and shipping firms who bargain through brokers. On the supply side, many shipping firms participate in this market, providing a variety of ship sizes and types. There are no real restrictions on entry, and grain shipping operates virtually without economic regulations. On the demand side, chartering is dominated by five multinational grain firms and by certain governments (H. P. Drewry, Ltd.). This suggests that rates are unlikely to deviate from costs for long, given the possibility that grain firms may expand their existing vessel ownership.[1]

Therefore, conventional concepts of cost were used to select variables for analyzing rate differences. Two equations (described below) were estimated. Each was of the following general form:

$$RATE = f(DIST, SIZE, TERMS, QUART, FLAG, VOL, PORT),$$

where *RATE* is rate (dollars per long ton);[2] *DIST*, voyage distance (thousands of miles); *SIZE*, shipment size (thousands of tons); *TERMS*, loading and unloading terms (explained below); *FLAG*, registry of ships (U.S. or foreign); *QUART*, quarter in which the shipment occurred; *VOL*, volume of grain trade on route in question, 1972–76 (hundreds of shipments); and *PORT*, origin/destination port area of shipment. This formulation does not include some factors that affect costs, most notably input prices. These are assumed to be sufficiently invariant across routes as to have no perceptible impact on cross-sectional differences.

Various hypotheses concerning the effects of these factors on rates are suggested by previous theoretical and empirical results. Obviously, increasing distance will increase costs and, hence, rates. While the exact nature of this effect is basically an empirical question, the results of Geraci and Prewo suggest that as distance increases, rates increase in a decreasing fashion. It is expected that rates in the last quarter of the year are higher, due to demands put on the shipping industry by harvests in Northern Hemisphere grain-producing areas (O'Loughlin). Ships operating under U.S. registry are known to charge higher rates, due to higher costs brought about by U.S. construction and operation restrictions. These ships depend upon cargo preference laws (e.g., P.L. 480 and Russian shipments) for survival, and essentially operate in markets separate from ships of other countries (Cayemberg).

It is reasonable to expect that as the volume of shipments on a route rises, the average rate charged will decline, because of favorable external effects. A more active trade route will involve ports with more efficient handling facilities, better ship provisioning and maintainence, and perhaps lower probability of long waiting times (Bennathan and Walters). In addition, a busy route is likely to generate more backhaul opportunities and, hence, less empty mileage.

The average size of bulk vessels has been rising recently. Because as size of ship increases, such factors as horsepower and manning requirements increase less than proportionally, use of larger ships presents a means of lowering costs, at least those costs incurred at sea. But there are conflicting views concerning the effect of ship size on port costs. Both Kendall and Janson and Schneerson have claimed that port costs rise with size of ship, and that optimal ship size depends upon the trade-off between at-sea economies and port diseconomies. However, Robinson, using regression on data from the Port of Hong Kong, found that larger ships spend less time in port than do smaller ships. Heaver and Studer examined grain shipment data from Vancouver, British Columbia, and found that larger vessels spend more time in port but have faster loading rates.

[1] Because of the nature of supply in ocean shipping, short-run rates often do not reflect costs. Since the data were indexed on a 1976 basis (described below), annual rate fluctuations were removed. Thus, it is only important that relative rates reflect relative costs differences.

[2] A long ton is 2,240 pounds. Throughout the balance of the discussion, the word "ton" is understood to mean "long ton."

In this study, a special effort is made to examine port costs as they relate to shipment size. An aspect of this involves examining interactions between size of shipment and charter terms, which determine responsibility for loading and/or unloading. There are three types of terms employed in the grain trade: "free in and out," in which the charterer pays both loading and unloading; "free discharge," in which the charterer pays unloading but the shipowner pays loading; and "gross terms," in which the shipowner pays both.[3] Any variations in these charges for different shipment sizes can provide information on the relationship between size of vessel and cargo-handling costs. There are port costs other than loading and unloading, such as ship waiting, movement in and out of the harbor, berth changes, and pilotage. These are reflected in rates; and if there exist port diseconomies and at-sea economies, one would expect the function relating rates charged by large ships to distance to have a larger intercept than the corresponding function for small ships (reflecting higher port costs) but a smaller response to distance (reflecting lower at-sea costs), apart from the effect of charter terms.

In order to examine these hypotheses, two linear models are estimated using ordinary least squares (OLS). The first is a relatively simple form, designed to examine the "average" effect of the variables described above. The second model is more complex, intended to explore issues dealing with economies of scale, port costs, and at-sea costs. The dependent variable in each equation is the rate in dollars per long ton. The independent variables in the first equation are distance and distance squared, shipment size and shipment size squared, volume of trade, and dummy variables for U.S. ship registry, gross terms, free discharge, and quarter in which the shipment occurred. The second equation is a covariance model (Johnston), in which coefficients needed to examine hypotheses dealing with scale economies are permitted to vary across shipment size classes. A set of six shipment size classes is substituted for shipment size and its square. Interaction variables between these and the two shipping term dummy variables are added, and slope shifter variables for the shipment size class variables on distance and distance squared are incorporated. This model also contains a set of port origin and estimation dummy variables, which will be discussed in a subsequent section.

Some words on the research methods used are appropriate. Linear equations (as opposed to a log form) are used to permit the separation of fixed (port) costs and variable (at-sea) costs, since port costs affect rates in an additive rather than a multiplicative fashion. The only real difficulty with the procedure relates to aggregation bias (Theil). The data used are observations on individual grain movements. Given the large number of factors likely to affect rates charged on a given shipment, it is clearly not possible that the variables used in the analysis have homogenous effects across observations. Thus, the results should be interpreted not as estimates of the response of rates on individual shipments but as representative of tendencies existing in ocean grain shipping. Although numerical results are of interest, the primary purpose of the study is to identify the relative role of major factors affecting ocean grain rates.

Data

The data used for the study are published ship charters for all grains and soybeans (Maritime Research). These list information on origin, destination, and tonnage of the shipment, name and flag of registry of the ship, rate, and shipping terms. All 1972–76 charters so published were compiled, yielding 9,356 observations.

Certain data modifications were performed. In order to eliminate the year-to-year variability characteristic of ocean freight rates, an indexing procedure was used to put all data on a 1976 basis. The indexes were constructed by calculating mean rates for all years, and then taking the ratio of the 1976 mean to that for each year. The rates were multiplied by the appropriate index. Different indexes were constructed for the major trading routes, and an overall index was used for others.

Because there are in excess of 1,000 individual origins and/or destination points in the sample, ports were aggregated into 16 origin and 34 destination regions, each with a basing point. The distances used in the analysis were based on these points and were obtained from the Marine Distance and Speed Table (Edward W. Sweetman & Co.).

Because the published charters do not ac-

[3] The obverse of free discharge, in which the charterer pays loading and the shipowner pays unloading (known as "f.o.b. terms") is seldom, if ever, used in grain shipping.

count for all movements, a proxy variable for the number of shipments was constructed. For each exporting country, the total volume of grain exports for the sample period was obtained (FAO). This was compared to total exports from each country represented in the sample.[4] The ratio of the former to the latter was calculated, and then the number of shipments in the sample from each port area was augmented by dividing it by the ratio for the country in question.

Table 1 presents some characteristics of the sample. There is strong evidence of scale economies, because average rates steadily decline as average shipment size increases. Also, loading costs appear to be much smaller than unloading costs (since the difference between gross terms and free-in-and-out far exceeds that between gross terms and free discharge). There is evidence that total handling costs can easily exceed at-sea costs, which supports the criticism made by Jansson and Schneerson of previous work: "Current ship-optimizing models are heavily 'at-sea biased' in spite of the fact that the costs incurred in port are generally of a comparable order or magnitude" (p. 288).

Empirical Results

The estimation results for the two equations are presented in table 2. First we will emphasize the "average" effects of the variables, equation (1). Then various interaction effects among the variables, equation (2), will be discussed.

Distance

As expected, equation (1) results indicate a nonlinear effect of distance. While the coefficient on distance is positive (1.988), the negative coefficient on the square of distance (−.061) implies a declining effect as distance increases. For example, the increment in going from a 3,000- to a 4,000-mile voyage is estimated to be $1.56 per ton. The corresponding increment for 5,000 to 6,000 miles is $1.31. Thus, even relatively large differences in distance between traders may not necessarily generate substantial trading advantages, at least in the typical case.

Shipment Size

From equation (1), the estimated coefficients on shipment size and shipment size squared (−.387 and .004, respectively) suggest the presence of scale economies over a large but not unlimited range. Based on data for free-in-and-out shipments in table 1, the average elasticity of rates with respect to shipment size is −.33. Increasing size by 5,000 tons from the sample mean reduces the per ton rate by 71¢. However, the effect of size on per unit rates becomes positive at approximately 50,000 tons, indicating diseconomies beyond that point. This almost surely cannot reflect rising at-sea costs, since at-sea economies are probably unlimited (Jansson and Schneerson). Thus, this evidence of diseconomies is likely to represent port costs, an issue explored below.

[4] The sample comprised the following percentages of exports by major grain producers for 1972–76: United States, 42%; Canada, 31%; Brazil, 48%; Argentina, 35%; Australia, 16%; South Africa, 41%; France, 3%.

Table 1. Rates, Sizes, Terms, and Distances for Sample Data

Shipment Size	Number of Shipments	Average Rate	Average Shipment Size	Average Distance
(Thousands of Tons)		($)	(Tons)	(Miles)
Less than 10	583	24.21	—	4,787
10–20	3,559	18.38	—	5,779
20–30	3,066	15.00	—	6,246
30–40	1,170	13.49	—	6,441
40–50	432	13.11	—	6,195
50+	546	11.95	—	5,540
Terms				
Free-in-and-out	6,233	14.10	25,446	—
Free discharge	2,945	20.67	19,360	—
Gross terms	178	38.03	24,065	—

Table 2. Regression Results

Variable	MODEL 1 Coefficient	MODEL 1 t	MODEL 2 Coefficient	MODEL 2 t
1. Constant	12.805	29.04	5.369	6.16
2. U.S. ship registry	11.390	41.92	10.621	38.83
3. Shipment size (1,000 tons)	−.387	−22.04	—	—
4. Shipment size squared	.004	15.45	—	—
5. Distance (1,000's miles)	1.988	14.93	3.408	9.88
6. Distance squared	−.061	−6.22	−.145	−5.05
7. Number of shipments on route, 1972–76 (100's)	−.254	−22.50	−.125	−6.72
8. January–March	−2.901	−14.98	−2.273	−12.37
9. April–June	−1.436	−7.45	−1.141	−6.35
10. July–September	−1.145	−5.93	−1.219	−6.78
11. Gross terms	11.058	20.58	12.365	10.63
12. Free discharge	2.908	17.55	1.474	2.51
Shipment size intercept shifters				
13. Tons 2: 10,000 ≤ tons < 20,000	—	—	2.251	2.56
14. Tons 3: 20,000 ≤ tons < 30,000	—	—	.836	.68
15. Tons 4: 30,000 ≤ tons < 40,000	—	—	6.259	3.21
16. Tons 5: 40,000 ≤ tons < 50,000	—	—	6.575	1.92
17. Tons 6: tons ≥ 50,000	—	—	6.272	2.10
Interactions between size and terms				
18. Tons 2 and gross terms	—	—	−2.497	−1.79
19. Tons 3 and gross terms	—	—	−6.285	−3.93
20. Tons 4 and gross terms	—	—	−9.138	−4.47
21. Tons 5 and gross terms	—	—	−4.606	−1.80
22. Tons 6 and gross terms	—	—	−11.863	−5.52
23. Tons 2 and free discharge	—	—	−.096	−.15
24. Tons 3 and free discharge	—	—	1.531	2.42
25. Tons 4 and free discharge	—	—	2.186	2.86
26. Tons 5 and free discharge	—	—	4.541	3.87
27. Tons 6 and free discharge	—	—	6.510	4.38
Slope shifters for distance				
28. Tons 2 with distance	—	—	−1.674	−4.42
29. Tons 3 with distance	—	—	−1.829	−4.18
30. Tons 4 with distance	—	—	−4.127	−6.44
31. Tons 5 with distance	—	—	−4.741	−4.39
32. Tons 6 with distance	—	—	−4.513	−4.65
33. Tons 2 with distance squared	—	—	.112	3.60
34. Tons 3 with distance squared	—	—	.097	2.80
35. Tons 4 with distance squared	—	—	.264	5.52
36. Tons 5 with distance squared	—	—	.330	4.20
37. Tons 6 with distance squared	—	—	.299	4.09
R^2	.49		.56	

Shipping Terms

The estimated coefficients on the dummy variables denoting shipping terms indicate that rate differentials attributable to handling costs are substantial but lower than implied by the data in table 1. The coefficient for gross terms suggests that inclusion of loading and unloading in the rate leads to an average increase of about $11 a ton; the corresponding increase for loading is $2. The difference in the regression results relative to a comparison of sample means implies that different shipping terms are quoted under different average circumstances. For example, the average distance for shipments quoted as free discharge is lower than that for the other categories (table 1).

Volume of Trade

In both models, the negative coefficient on the number-of-shipments variable and the level of

statistical significance, particularly in equation (1), suggest external economies in ocean shipping, perhaps of fairly substantial practical significance. The estimated coefficient from equation (1) (−.25) implies that increasing shipments on a route by 100 over a five-year period (e.g., a sustained increase of 20 per year) would tend to be associated with a rate reduction of about 25¢ a ton. This does not mean increasing trade volume (for whatever reason) will automatically lower rates. Part of the effect identified may reflect the presence of efficient port facilities, which are associated with high volume routes. The volume may justify the improved facilities, which in turn lead to lower rates. On the other hand, trade volume itself may generate lower rates through increasing the availability of backhauls. Relevant to this, estimation of the second equation (which suggests that volume is of lesser importance than does the first) with no destination variables but with port origin variables yielded a coefficient virtually identical to that in equation (1). The decline in magnitude with the addition of port destination variables implies that part of the volume effect reflects backhaul availability at destinations. Again, however, it could be reflecting the presence of efficient off-loading facilities. It is difficult to determine whether the negative correlation between rates and volume is direct or due to joint correlation with other factors. Undoubtedly both effects are present.

Other Factors

For both models, the magnitude of the coefficient denoting U.S. flag vessel ($10–$11/ton), coupled with its extremely high level of statistical significance, certainly supports the viewpoint that U.S. and foreign flag vessels operate in different markets.[5] This has important implications for any policy designed to expand cargo preference laws for U.S. shipping, as occasionally has been proposed. The estimated coefficients on the seasonal variables indicate that rates in the last quarter of the year are highest. The lowest rate occurs in the first quarter, perhaps caused by the closing of several important port areas during the winter months, temporarily increasing the supply of ships for other port areas, and from seasonal drops in export demand.

Interaction Effects

As stated above, in equation (2) shipment size dummy variables are used in lieu of a continuous variable, with interactions between these and other variables. The size classes are the same as those in table 1, necessitating five dummy variables, with the smallest size class being the "omitted" class from the dummy set. Hence, coefficients on variables involving these classes measure differences as compared to the smallest class.

The estimated coefficients for interaction variables between shipment size and terms display opposing tendencies. For gross terms, they exhibit a downward trend in the premium charged for loading and unloading as shipment size increases. The corresponding estimates involving interaction between shipment size and free discharge (which only involves loading) exhibit an opposite trend. These results suggest economies of scale in discharging cargo and diseconomies in loading, which does not accord well with expectations. Grain-loading ports tend to have more specialized facilities than receiving areas (*Cargo Systems*). Thus, if inadequate port facilities inhibit the use of larger ships, larger vessels should incur higher costs for unloading rather than loading. The result is especially puzzling in view of the fact that many charters quoted under gross terms are destined for less developed countries, which are known to have limited facilities (see table 4 below). Evidently, there are specific factors at work that are not represented in the data, such as a tendency for free discharge to be specified for shipments arising from ports with limited facilities. This cannot be examined because published charters rarely state the exact port of origin, and port areas have significantly differing facilities (even within a single port).[6]

Given the number of observations involved, it is doubtful that the results with respect to gross terms reflect general tendencies of the

[5] However, estimates made by the Office of Management and Budget and reported in *The American Shipper* are considerably higher. For the period 1972–76, OMB's calculations indicated a per-ton rate subsidy ranging between $13.87 and $33.29, considerably higher than the estimates of $11.00 obtained here. Part of this difference stems from the fact that the present study was confined to bulk shipments; shipments of bagged grain were eliminated. Some P.L. 480 shipments involve bagged grain, and these move at high rates, generally at least twice the magnitude of those for bulk shipments.

[6] Table 4 below indicates a greater tendency for free discharge to be specified from certain ports areas than from others. Thus, the results with respect to free discharge probably do reflect some port specificity and, of more importance, individual facility specificity.

population.[7] The results for free discharge are more credible, although possible aggregation bias suggests they, too, should be interpreted with caution. The indication is that loading costs increase rather sharply with ship size. One would expect this to be less true for ports with superior facilities than for those with limited facilities. Grain-handling terminals specifically designed to accommodate large vessels as well as small do exist, and large ship-loading disadvantages can at least partially be overcome (H. P. Drewry; *Cargo Systems*). The estimation results can be viewed as indicating that the benefits from modernized facilities may be substantial.

The other interaction effect examined was to determine whether the functions relating rates to distance vary across shipment size class. This involved the intercept shifters (variables 13 through 17) and the slope shifters for distance (variables 28 through 32) and distance squared (variables 33 through 37). In general, the estimation results support the diseconomies in port, economies-at-sea hypothesis, but not overwhelmingly. The shipment-size intercept shifters display a vague upward trend, but it is not consistent, and the estimates carry a fairly low level of statistical significance. But the general tendency is for the intercepts (and hence port costs other than cargo handling) to rise with shipment size.

The slope shifter for distance indicates a tendency for the slope coefficient on distance to decline for larger shipment sizes, implying that, as distance increases, rates do not rise as much for large shipments as they do for small. But the slope shifter for the square of distance produces an opposite effect: as shipment size increases, so does the coefficient on distance squared. For the larger shipment size classes, the overall shape of the estimated function relating rates to distance is that of a U. The downward-sloping portion occurs for short distances (few large shipments move short distances) and probably reflects a confounding with port costs, as represented by the intercept. Within the range of typical voyage distances (2,500 to 8,000 miles), the function implies a much smaller rate increase as voyage lengthens than is true of the lower size classes.[8] The portion of the function where, due to the effect of distance squared, the slope is positive and increasing (implying a rise in rates more than proportional to the increase in distance) occurs for high values of distance. This surely does not reflect ship-operating characteristics. A plausible explanation is that longer voyages are usually outside major trading routes, often bound for less developed countries (LDCs), and are thus somewhat atypical. However, there may be some inherent disadvantages to using very large ships on long routes, relating to difficulties of finding backhaul traffic to use vessel capacity efficiently, particularly from LDCs.

Analysis of Port Areas

A producer's competitive position in the world grain trade depends upon its comparative advantage in shipping as well as in production. An obvious component of the former is closeness to markets. This study provides evidence that distance may be of relatively small consequence if large vessels are employed, suggesting that a critical factor in shipping advantage is the nature of port systems at origins and destinations. The type of port facilities available, including channel depths, determine the types of ships that can be handled efficiently. A second factor is the location of ports with respect to major trading routes. The effect of trading volume on rates suggests that ship availability can affect a port area's comparative advantage, and hence a port area along a major trading route may enjoy lower shipping rates than one less favorably located.

In table 3 appear the average shipment size and average rate charged for the sixteen major port origin areas included in the sample data, and for four destination areas: North Central Europe, Japan, LDCs, and the rest of the world.[9] The former two are the only major importing areas for bulk agricultural commodities with highly developed port facilities (*Bulk-Systems International*). LDCs generally are located outside major trade routes and have limited facilities. There are significant ship-

[7] There were only sixteen charters in the largest tonnage class quoted under gross terms, twelve of which were on two routes. The results imply virtually no charge for cargo handling for this size class. This cannot be accepted as a characteristic of the population.

[8] For example, in going from a 3,000- to 5,000-mile voyage, the estimated incremental per ton charge in dollars is (by increasing size class) 2.38, 2.94, 2.38, .47, .30, .27; for an increase from 5,000 to 7,000 miles, it is 5.44, 4.30, 1.99, 1.42, 1.76, 1.49.

[9] The choice of LDCs was based on the criterion of countries with 1978 per capita income of $478 or less (U.S. Department of State). These are basically India, Pakistan, Bangladesh, and most of Africa.

Table 3. Origin Port Area Data and Regression Results for Port Variables

Port Area	Number of Observations	Gross Terms	Free Discharge	Average Rate ($/ton)	Average Shipment Size (tons)	Regression Coefficient	*T* Statistic
Origins							
U.S. Gulf	4,386	73	838	11.94	26,689	—	—
Brazil	362	0	11	14.28	18,453	1.143	2.94
Argentina	641	0	580	17.75	18,041	−.358	−1.09
California	64	3	26	18.10	15,376	.856	1.09
U.S. North Pacific	722	60	552	21.79	20,877	3.493	12.41
Canada, West Coast	194	14	56	16.39	20,544	1.716	3.48
Canada, Great Lakes	135	0	11	17.90	15,580	5.389	9.27
U.S. Great Lakes	631	2	55	17.13	17,619	4.753	15.32
Canada, East Coast	45	0	5	6.98	22,790	−2.307	−2.36
Canada, St. Lawrence	467	11	68	9.38	28,194	−.519	−1.48
U.S. East Coast	919	8	117	11.12	25,133	−1.006	−3.78
France	102	3	22	14.82	16,381	−.375	−.59
South Africa	373	0	360	13.90	15,721	−2.599	−6.22
Thailand	22	1	2	16.00	14,258	−2.589	−1.95
Australia, West Coast	100	0	98	18.51	20,345	1.346	2.04
Australia, East Coast	195	0	141	17.40	20,757	2.776	5.69
Destinations							
Less developed countries	1,063	115	701	24.91	23,410	4.137	16.69
Japan	1,255	0	407	12.36	23,360	−2.422	−8.63
North Central Europe	2,104	2	194	9.73	31,683	−1.207	−4.62
Rest of world	4,934	58	1,640	15.36	19,976	—	—

ment size differences among ports, with a negative association between size and rate. The association is not perfect, of course, due to the complexity of the relation between rates and size and the presence of other differences among port areas that impact on rates. Some of these are included in the regression models above. However, others are not. To account for these, a set of fifteen origin dummy variables and a set of three for destinations are included in equation (2). The regions omitted from these two sets were the U.S. Gulf and the rest of the world, respectively.

The resulting regression coefficients appear in table 3. These indicate that, after allowing for the other factors in the equation, some significant differences in shipping rates from/to port areas remain. The results generally support the hypothesis that rates from port areas near major trading routes (e.g., South Africa, the eastern part of the United States, and Canada) are lower than those from areas less favorably located (e.g., the Great Lakes area, the North Pacific Coast, Australia).

The data in table 3 indicate that LDCs are at a competitive disadvantage in world agricultural trade. The average rate to LDCs is more than twice that to North Central Europe and Japan and substantially above the average to other areas. Much of this is evidently explained by factors in equation (2), for differences in dummy variable coefficients are smaller than differences between sample means. Such factors include a disproportionate use of U.S. ships and charters involving handling costs; also, LDCs are relatively far from producing areas and have low trade volumes. Even though shipment sizes are reasonably large, the distance from exporters and major trading routes evidently negates any advantages from use of large ships, as noted above. The remaining LDC disadvantage (as measured by the dummy variable) probably reflects the costs of inadequate ports. Conversely, the negative coefficients for the Europe and Japan dummy variables suggest some combination of the effect of major trading routes and efficient port facilities.

Using study results, the analysis of shipping advantage can be extended. As an example, shipments to North Central Europe from several port areas active in that trade were examined. Because the Gulf is the major exporting area to Europe, the Gulf region was used as a standard of comparison. The results of the procedure appear in table 4. The first column is the difference between the average sample rate from the origin to Europe and the corresponding rate from the U.S. Gulf (which was $5.82). The U.S. Gulf has a comparative advantage in this trade, with substantially lower rates than South American or Great Lakes

Table 4. Analysis of Rate Differences between Major Origins and North Central Europe, as Compared to U.S. Gulf

		Difference		
Origin Area[a]	Actual	Due to Distance and Shipment Size	Due to Distance	Due to Volume of Trade
Brazil	6.65	3.10	.36	2.35
Argentina	11.20	5.55	1.13	2.28
Canada Great Lakes	11.07	3.08	−.35	2.42
U.S. Great Lakes	10.07	2.55	−.31	1.77
Canada East Coast	−.93	−.60	−.98	2.64
Canada St. Lawrence	.15	−.53	−.88	2.16
U.S. East Coast	.62	.07	−.71	1.88

[a] In the order of origins on the table, the distances are (in nautical miles) 5,446, 6,360, 4,369, 4,444, 2,796, 3,178, 3,636; U.S. Gulf = 4,939. Average shipment sizes were 20,992, 16,189, 15,619, 18,426, 26,203, 38,359, 28,730; U.S. Gulf = 42,887. The number of observations were 147, 126, 75, 322, 20, 140, 284; U.S. Gulf = 923.

origins. Only Eastern Canada has a lower sample rate. The remaining columns were computed from equation (2). For each origin, the percentage of traffic on this route in each of the six shipment size classes was computed. Using the appropriate distances, the rate for each tonnage class between the sets of points was estimated, ignoring all factors other than distance and the intercepts. Based on the percentages, a weighted average rate was computed. The second column is the difference between the weighted rate for each origin and that of the Gulf. It thus estimates the advantage of the Gulf due to its distance from Europe and its shipment size distribution. Column three was computed in the same fashion, except that the shipment size distribution for the Gulf was used for all origins. Since shipment sizes for all origins are equalized, this estimates the role of distance alone in determining advantage. The last column is (negative of) the difference between the estimated rate reduction on each route caused by trade volume and the reduction for the U.S. Gulf. In the table, positive entries denote a comparative advantage for the U.S. Gulf, negative entries a disadvantage.

Based on this procedure, the U.S. Gulf has an advantage due to volume and size. (The conclusion concerning size follows from comparing column 3 to column 2). The trade volume advantage underscores the importance of domestic-export transport inter-relationships, for the Gulf's location with respect to inland transportation (particularly the Mississippi River) gives it a high level of shipping activity. It is only for distance that the Gulf has any comparative disadvantage. Note that, if all origin areas had a shipment size distribution as favorable as the Gulf's, the effect of distance on this trade would not be particularly strong. The maximum differential attributable to distance under this procedure is about $2.00 a ton (Canada East Coast vs. Argentina).

Distance, shipment size, and trade volume do not explain all the differences in the sample rates in column 1. Other factors in the equations also play a role. But many of these also reflect port characteristics, such as adequacy of handling facilities and harbors and location relative to major areas of shipping activity, and are related to distance, shipment size, and trade volume. Although the decomposition of ocean freight rates into identifiable components is quite difficult, the results of this study indicate that distance, shipment size, and trade volume are primarily responsible for rate differentials, and that generally none is dominant.

Implications and Conclusions

The most important implications of this study pertain to the relationship between international shipping and the comparative position of countries in the world grain trade. At present, North American producers dominate this trade, with the U.S. and Canada accounting for over two-thirds of seaborne grain shipments. Much of this developed because of production efficiencies (Johnson). However, these countries have transportation advantages: they are well-located with respect to major markets and have relatively efficient ports, many with a high level of shipping activ-

ity. The continuing growth in trade gives other producers incentive to improve both production methods and export marketing, leading to a more competitive trade environment.

The trend toward improved grain-handling facilities and larger vessels suggests a decline in the role of distance in determining patterns of international trade. The study results show that larger ships lead to lower at-sea transport charges. The measurement of the interaction between ship size and port costs did not yield a clear-cut answer, but the evidence points toward a positive relationship. If this is so, inadequate port facilities will hinder further savings in shipping. This is probably why some major exporters recently have made substantial port investments. Such investments are likely to be the primary source of future cost savings in export grain handling. Port areas that make them will benefit vis-à-vis those that do not.

The results show a negative association between a route's grain trade volume and shipping rates. While this reflects the association between traffic volume and efficient port facilities, such factors as backhaul availabilities and ship maintenance are partly responsible for this finding. These external effects, in the long run, may be the most important source of rate differentials among shipping areas. The volume of seaborne trade depends on many factors outside the discretion of individual traders. However, trade policy can affect trade volume. Countries restricting imports not only reduce backhaul opportunities for ships carrying exports, they may find that reduced trade makes investment in port facilities less attractive.

The importance of shipping density has other implications. Small importers may not be able to generate sufficient trade to benefit from high levels of shipping activity, and their erratic demand may preclude the construction of efficient grain off-loading facilities (*Cargo Systems*). Thus, gains may arise if certain well-developed ports serve as transshipment centers, with small vessels serving as the distribution system, a procedure used in Europe. But institutional and geographic constraints may inhibit its application elsewhere. Thus, LDCs may find themselves at a continuing disadvantage in world trade, worsening problems brought by rising food and fuel prices.

For an exporter with several port areas, such as the United States and Canada, port expansion decisions should include the effects of the density factor. The results imply that expansion should occur in the areas with relatively heavy ship traffic. But optimal port improvement and location depend upon the trade-off between inland and export transportation costs. The efficiency of the U.S. export grain transport system perhaps could be enhanced by a combination of domestic transport changes (such as the introduction of long-haul unit trains to certain ports) and port improvements. But neither change may be justified without the other, and it is difficult to effect such changes without coordinating policy. Knowledge of both domestic and export transportation, such as that provided by this study, will assist in evaluating these tradeoffs.

Finally, the study results indicate that relative transport costs between producers and importers do not necessarily, nor even primarily, reflect unalterable geographic factors, but are more a function of transport and port technology and overall patterns of trade, both of which are policy-relevant. This suggests that the effects of changes in international transport costs on trade is itself worthy of study, and that international trade research which does not consider transportation factors may be based on misconceptions and may generate erroneous conclusions.

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Rural Financial Market Performance: Implications of Low Delinquency Rates

Robert C. Vogel

In contrast to most developing countries, nonrepayment of agricultural loans has not been a problem for the Costa Rican banking system. Delinquency rates have in fact been lower for agricultural than nonagricultural loans and lowest on loans to small farmers. This good performance is due largely to efficient techniques developed for gathering information about potential borrowers and incentives for borrowers to repay promptly to maintain access to bank loans which carry interest rates substantially below equilibrium. The pattern of low delinquency rates reflects the structure of low interest rates which causes farmers, especially small farmers, to be rationed most severely.

Key words: agricultural credit, Costa Rica, credit rationing, delinquency rates, interest rates.

Low rates of delinquency and default often have been the primary criterion used to measure the success of agricultural credit programs in developing countries. This widespread concern with good repayment records is amply documented in various volumes of the Agency for International Development's (AID) *Spring Review of Small Farmer Credit* (Gonzalez-Vega). Low default and delinquency rates are said to be particularly praiseworthy because they indicate that lenders are careful in their selection of borrowers and forceful in their collection of loans. Good repayment records also are said to indicate that loans are being allocated to productive activities because enough additional income is being generated to repay the loans.

This paper argues that low default and delinquency rates do not necessarily indicate that an agricultural credit program is performing satisfactorily. This does not mean that good repayment records are not necessary for a successful credit program, but rather that they are not a sufficient condition for success. The overriding concern with loan repayments can be explained, if not justified, by the high delinquency rates which typically have plagued agricultural credit operations in developing countries. In contrast to the widespread repayment problems reported by Bottomley (pp. 282–7), Donald (pp. 137–53), the World Bank (pp. 140–3), and the AID *Spring Review*, low delinquency rates characterize agricultural credit operations in Costa Rica, the case to be examined in this paper. However, these low delinquency rates have been achieved in part at the cost of a perverse selection of borrowers; that is, small farmers who are supposed to be the main beneficiaries of the Costa Rican agricultural credit system are in fact rationed more stringently in their access to credit than other classes of borrowers.

The evidence on delinquency rates in Costa Rica presented in the next section of this paper shows not only that overall delinquency rates are quite low, but also that delinquency rates tend to be lower for agricultural than for nonagricultural loans and lowest on loans to small farmers. This unusual pattern is worthy of detailed analysis, if not emulation. However, the analysis which follows reveals negative as well as positive aspects to this pattern of delinquency rates. The Costa Rican agricultural credit system is worthy of emulation in that it efficiently processes information about the probable repayment performance of potential borrowers and provides incentives that encourage borrowers to repay promptly. One of the main incentives for prompt repayment is

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the promise of continued access to credit at interest rates substantially below market equilibrium, but this interest rate structure also provides lenders with an incentive to lend only to those small farmers who are judged to be less risky than potential borrowers in other categories. Moreover, the subsidy implicit in these below-equilibrium interest rates makes it impossible to conclude that good repayment records show that loans are being allocated to productive activities.

Evidence of Low Delinquency Rates

The banking system in Costa Rica consists of a central bank and four commercial banks, all owned by the government of Costa Rica. These four commercial banks are the predominant source of agricultural credit in Costa Rica and provide virtually all of the institutional credit for agriculture (see Vogel and Gonzalez-Vega, especially pp. 10–35, 147). The commercial banks also lend substantial amounts for nonagricultural purposes, but agricultural lending (including both crops and livestock) is the primary component and comprises almost half of the total portfolio (see Banco Central de Costa Rica). The first set of data on delinquency rates to be examined pertains to all four commercial banks and includes nonagricultural as well as agricultural loans. For two commercial banks, more detailed information is available on delinquency rates for agricultural loans, and these latter data provide the basis for most of the main conclusions.

Delinquency rates for the commercial departments of the four banks as of the end of each year 1969–74 are reported in table 1. These delinquency rates are measured by the total value of loans with any payment of interest or principal overdue as a percentage of the total value of loans outstanding. However, some researchers, such as Donald (pp. 138–9), have suggested that delinquency rates might better be calculated on the basis of the value of loans disbursed or falling due during a year. In the case of Costa Rica, such alternative bases for calculating delinquency rates would make little difference. Because of the predominance of short-term loans, the amount falling due each year has averaged over 80% of the amount outstanding at the end of each year, so that delinquency rates calculated on this basis would be only slightly higher than the rates reported. Delinquency rates calculated on the basis of amounts disbursed actually would be slightly lower than the rates reported because of the approximately 20% per year growth in lending.

The data in table 1 initially seem to suggest that delinquent loans may be a problem for Costa Rican commercial banks as approximately one-third of credit outstanding is overdue. However, only 3%–4% have payments more than one year overdue, and the percentage of credit between ninety-one days and one year overdue has declined over the 1969–74 period. Moreover, the high proportion of credit with payments between one and ninety days overdue should not be taken to indicate a serious delinquency problem because it reflects primarily Costa Rican bank policy. Judicial proceedings against delinquent borrowers are not initiated until payments are ninety days overdue; but thereafter, delinquent borrowers are actively pursued. Judicial proceedings may be suspended if an agreement can be reached for reasonably prompt repayment, so that only about half the credit more than ninety days overdue is actually under judicial proceedings.

As stated above, more detailed information on delinquency rates is available for two of the four commercial banks. The first of these is the Banco Nacional de Costa Rica, which is by far the most important as it accounts for almost half of total bank credit and almost 60% of bank agricultural credit. In addition, the

Table 1. Commercial Departments of Costa Rican Commercial Banks: Delinquent Loans as a Percentage of Credit Outstanding at End of Year, 1969–74

	1969	1970	1971	1972	1973	1974
1–90 days overdue	19.78	18.11	24.05	24.16	26.84	25.59
91 days–1 year overdue	9.47	8.29	7.53	7.97	7.50	6.34
More than 1 year overdue	4.06	3.69	2.82	3.41	4.03	3.04
Total overdue	33.31	30.09	34.40	35.54	38.37	34.97

Source: Banco Central de Costa Rica, Auditoria General de Bancos, unpublished records.

Rural Credit Department of the Banco Nacional has long been a pioneer in lending to small farmers and continues to be an important source of agricultural credit (see Gonzalez-Vega).[1] Table 2 reports the delinquency rates at the end of each quarter of 1974 for the Rural Credit Department and the three components of the Banco Nacional's Commercial Department: the central office, the financiera section, and the regional offices. The figures in tables 1 and 2 are mutually supportive in two respects. First, most delinquency rates are reasonably stable during the year and, in particular, year-end delinquency rates do not systematically understate end-of-quarter delinquency rates. Second, year-end delinquency rates for the total Banco Nacional correspond quite closely to 1974 delinquency rates for the four banks combined, which suggests that the patterns observed for the Banco Nacional may accurately describe the other three banks.

The most significant pattern which emerges from table 2 is that delinquency rates are substantially higher for the central office and the financiera section than for the regional offices and the rural credit department. This pattern closely parallels appreciable differences in average loan size and in purposes for which loans are granted (see Banco Nacional de Costa Rica). Less than 10% of the credit from the financiera section and about 60% from the central office is for agriculture, in contrast to more than 80% from the regional offices and 99% from the rural credit department. In addition, average loan size for the central office is more than 300,000 colones, in contrast to approximately 100,000 colones for the regional offices and less than 10,000 colones for the rural credit department (8.57 colones equals one U.S. dollar). Thus, lower delinquency rates appear to be associated with smaller loans and with lending for agricultural purposes.

The other commercial bank for which more detailed information is available on delinquency rates is the Banco Anglo Costarricense. The Banco Anglo is the third largest bank and accounts for almost 15% of bank agricultural credit and more than 15% of total bank credit (see Banco Anglo Costarricense). The detailed information on the Banco Anglo is particularly useful because delinquency rates are reported for different categories of loans and because loans which are on time without extensions or other forms of refinancing are distinguished from those loans for

[1] To qualify as a small farmer under Costa Rican banking regulations, a borrower must have a net income of less than 25,000 colones and total bank loans of less than 100,000 colones, and these same limits apply to all clients of the Banco Nacional's rural credit department.

Table 2. Commercial and Rural Credit Departments of the Banco Nacional: Delinquent Loans as a Percentage of Credit Outstanding at End of Quarter, 1974

	Central Office	Financiera Section	Regional Offices	Rural Credit	Total
March 31					
1–90 days overdue	16.91	33.39	22.46	16.71	19.18
91 days–1 year overdue	12.23	9.85	1.39	2.38	8.15
More than 1 year overdue	2.80	3.05	1.10	1.35	2.22
Total overdue	31.94	46.29	24.95	20.44	29.55
June 30					
1–90 days overdue	16.94	29.97	23.98	16.49	19.17
91 days–1 year overdue	8.99	9.94	2.00	2.28	6.59
More than 1 year overdue	2.58	2.78	0.94	1.29	2.07
Total overdue	28.51	42.69	26.92	20.06	27.83
September 30					
1–90 days overdue	20.33	30.48	20.37	16.62	20.72
91 days–1 year overdue	6.29	8.02	2.24	2.33	5.07
More than 1 year overdue	2.94	2.40	0.86	1.35	2.25
Total overdue	29.56	40.90	23.47	20.30	28.04
December 31					
1–90 days overdue	25.73	27.33	21.42	22.96	24.70
91 days–1 year overdue	10.70	5.68	1.78	2.54	7.13
More than 1 year overdue	2.88	1.95	0.64	1.26	2.10
Total overdue	39.31	34.96	23.84	26.76	33.93

Source: Banco Nacional de Costa Rica, unpublished records.

which extension or refinancing has been granted. The percentage of credit delinquent and with extensions or other forms of refinancing is reported in table 3 for the Banco Anglo as of the end of June 1974.

An important conclusion which emerges from table 3 is that a generous policy of loan extensions and refinancing is not primarily responsible for low delinquency rates in Costa Rica. Just 10% of livestock credit is on time because of extension or refinancing, and even this compares with only 2%–3% for crop and small farmer loans. In addition, delinquency rates for the Banco Anglo confirm the patterns indicated by the data for the Banco Nacional. Among the different categories in table 3, delinquency rates tend to be lowest on crop, livestock, and especially small farmer loans. The percentage of credit between 91 and 360 days overdue and more than 360 days overdue is particularly low for the agricultural categories, especially for small farmers.

The evidence presented above leads unequivocally to the conclusion that delinquent agricultural loans are not a serious problem for Costa Rican commercial banks. In fact, delinquency rates in Costa Rica tend to be lower for agricultural than for nonagricultural loans and to be lowest of all on loans to small farmers. As noted initially, this experience stands in marked contrast to the widespread repayment problems for most agricultural credit operations in developing countries, especially when the lending agency is a government institution.[2]

[2] Delinquency rates on bank agricultural loans in Costa Rica are not appreciably higher than delinquency rates in the United States on loans from Federal Land Banks and Production Credit Associations and appear to be somewhat lower than delinquency rates on loans from the Farmers Home Administration.

Causes of Low Delinquency Rates

Two attributes of the Costa Rican banking system are primarily responsible for the pattern of low delinquency rates achieved. The first is that the Banco Central de Costa Rica establishes the interest rates at which commercial banks can lend, and these interest rates have been set well below the equilibrium levels which would equate demand with supply. From before 1969 through September 1974, interest rates on agricultural loans were set at 8% or 9% (plus commissions of 1%–2% on some loans), while interest rates on various types of nonagricultural loans were set as high as 13% plus commissions. Small farmers are charged the lowest rate, 8%, and pay no commissions.[3] The stated objective of these low interest rates is to promote developmental activities, especially in the agricultural sector, and to benefit disadvantaged borrowers, particularly small farmers. However, the main result of such below-equilibrium interest rates is an excess demand for credit which necessitates some form of rationing.

Excess demand for bank agricultural credit in Costa Rica has been documented thoroughly in a 1969 survey by Vogel and Gonzalez-Vega that includes interviews with more than four hundred farmers and more than fifty bank officials. Those interviewed reported that loan applications were rejected and amounts lent were limited because the

[3] Faced with mounting inflation, the Banco Central raised interest rates somewhat at the end of September 1974. Interest rates on some agricultural loans were set as high as 11% and for some nonagricultural loans as high as 18%, but loans to small farmers remained at 8%. These changes are too late and too small to have influenced the behavior of delinquency rates for the period covered in this paper.

Table 3. Commercial Department of the Banco Anglo Costarricense: Delinquent Loans as a Percentage of Credit Outstanding by Category as of 30 June 1974

	On Time without Extension	On Time with Extension	Total Overdue	1–90 Days Overdue	91–360 Days Overdue	More Than 360 Days Overdue
Crops	85.85	2.30	10.85	6.11	1.28	3.46
Livestock	77.35	10.10	12.55	10.34	1.94	0.27
Small farmer	91.90	3.31	4.79	3.25	1.20	0.34
Industry	74.71	5.20	20.09	9.93	5.84	4.32
Commerce	49.95	15.47	34.58	13.97	8.33	12.28
Service	76.57	7.05	16.38	7.92	2.82	5.64
Other	54.98	4.53	40.49	26.10	13.15	1.24
Total	77.51	5.25	17.24	10.40	3.79	3.05

Source: Banco Anglo Costarricense, unpublished records.

demand for credit by qualified borrowers at low bank interest rates substantially exceeded the funds available. Many farmers reported borrowing from nonbank sources at higher interest rates, and even those farmers with bank loans reported using on the average 1.5 nonbank sources of agricultural credit. No comprehensive survey has been carried out since 1969, but the excess demand for bank agricultural credit almost certainly has increased because higher rates of inflation have reduced real interest rates to negative levels in 1973 and 1974. The rate of inflation in Costa Rica remained well below 5% per year through 1969, hovered around 5% from 1970 through 1972, and then accelerated dramatically to 15% in 1973 and well over 20% in 1974.

Promises of continuing access to bank credit at interest rates well below equilibrium can provide borrowers with strong incentives to repay loans promptly. However, as the AID *Spring Review* thoroughly documents, low interest rates on bank agricultural loans are as widespread as repayment problems in developing countries. What distinguishes Costa Rica from the high delinquency rates found elsewhere is the promise of more low interest rate bank credit in the future if repayment is prompt, but not otherwise. Costa Rican farmers are aware not only of the longevity and continuity of the banking system and of the increasing amounts of credit available for agriculture, but also of the sanctions for failing to repay promptly. Even if the only sanction were the refusal of future loans, most Costa Rican farmers would nonetheless repay promptly because the likelihood of a larger low interest rate loan in the future outweighs in most cases the transaction costs of repaying and negotiating a new loan.

The relatively high proportion of loans between one and ninety days overdue provides an important illustration of the trade-off between prompt repayment and delinquency. In spite of the absence of explicit sanctions during the first ninety days, the majority of borrowers nonetheless repay on time and thereby avoid the possible damage to their reputations which might restrict future access to bank loans. Those borrowers who delay repayment for up to ninety days apparently find that the profitability of employing these resources for the additional time outweighs the possible damage to their credit worthiness. The increase after 1970 in loans between one and ninety days overdue (see table 1) may well reflect a change in this delinquency-repayment trade-off associated with increasing inflation in Costa Rica. Higher rates of inflation imply lower real interest rates which, other things being equal, make it more profitable to delay repayment for up to ninety days.

The second attribute responsible for the pattern of low delinquency rates is the internal operation of the Costa Rican commercial banks and, in particular, the incentives which lead bank officials to ration credit in a certain way and the mechanisms which have been developed to obtain information about the probable repayment performance of potential borrowers. It should be noted initially that the long tradition of professional banking in Costa Rica and the high salaries compared to most government and many private-sector institutions make it quite easy for the banks to attract highly qualified personnel. Because the commercial banks are government institutions, these personnel might be more strongly motivated to promote developmental activities and to aid the disadvantaged than to maximize profits. However, nonprofit objectives are given little weight for a variety of reasons. Allocating credit to projects with good repayment prospects, and thereby promoting bank profits, can readily be justified as supporting projects with high returns and hence promoting economic development. The low interest rates established for disadvantaged groups (e.g., small farmers) can be an excuse for not giving additional consideration to these groups in allocating credit.

Profit maximization is the dominant objective, mainly because it directly benefits bank employees. Salary increases are based in part on bank profits, and a portion of profits is channeled into pension funds and other fringe benefits for bank employees. Promotion is influenced in part by the profitability of the office or operation for which an employee is responsible. In addition, profitable banks grow more rapidly, and working for a large and growing bank can provide more power and prestige, as well as a higher salary.

In an attempt to assure some compliance with the objectives of promoting development and aiding the disadvantaged, the Central Bank sets various upper and lower limits on the amount of bank credit for certain activities and groups of borrowers. However, Gonzalez-Vega (pp. 20–30) argues convincingly that these credit limits are not part of any systematic plan, but rather are based largely

on projections of historical trends and are also quite vulnerable to political influence. Because the credit limits are often not binding and bank officials generally have some flexibility in allocating credit, even these limits have come to reflect profit considerations as much as development or welfare objectives.

Various models have been developed to explain bank lending under conditions of profit maximization (see, for example, Jaffee and Modigliani). The Costa Rican case is simpler in most respects because interest rates are fixed, so that bank officials can influence revenues only by varying the amounts lent in each category (within the credit limits). Allocating credit under conditions of excess demand to minimize costs thus becomes the primary focus of the analysis, and costs can be divided conveniently into four components: (*a*) cost of funds, including opportunity costs; (*b*) fixed costs associated with processing each loan; (*c*) costs resulting from delinquency and default; and (*d*) costs incurred attempting to reduce the probability of delinquency and default.

The first two costs can be dealt with quite simply. Although certain categories of activities and borrowers have special lines of credit from the Central Bank or foreign sources, there is no evidence that the cost of funds differs among categories at the margin. The fixed costs of processing a loan will, of course, decline per dollar lent as loan size increases. The last two costs involve a tradeoff, as the risks of delinquency and default can be reduced by obtaining more information about potential borrowers and their prospective projects before loans are made and, afterwards, by pursuing problem borrowers more diligently. Higher costs of obtaining information about a particular category of borrowers imply, other things being equal, less information gathering and hence higher perceived risks of delinquency and default for that category.

The mechanisms developed in Costa Rica to obtain information at low cost about the probable repayment performance of potential borrowers are particularly important because in most developing countries the high cost of obtaining such information has severely limited the access of small farmers to bank credit. The Costa Rican banks are quite decentralized, in that most loans can be approved at local offices by branch managers (who typically are trained in agriculture as well as banking) together with local boards of directors. Each local board is composed of three residents of the area, mostly successful farmers, who are intimately aware of the reputations of potential borrowers for honesty and ability as farmers. This innovative approach to evaluating loan applications (see Gonzalez-Vega, especially pp. 43–48, 96–100) was begun as early as 1914 by the predecessor of the Banco Nacional's rural credit department and, more recently, has been adopted by the other three banks' small farmer credit offices.

Statements made by Costa Rican bank employees during the 1969 agricultural credit survey (and reiterated more recently to the author) indicate clearly the costs of obtaining different kinds of information and the value of this information in reducing the risks of delinquency and default. According to these statements, the main criteria used to evaluate potential borrowers are prior economic success, especially in farming, and a reputation for fulfilling past obligations. Such information can be obtained quickly and cheaply from bank records and from the knowledge of residents who serve on local bank boards. On the other hand, investment plans showing the anticipated returns from projects receive almost no weight in loan approval decisions, even though such investment plans normally are a required part of loan applications. The detailed analysis necessary to make these investment plans useful in projecting returns would be costly and time consuming. Moreover, with low, even negative, real interest rates on bank agricultural loans, most projects proposed by successful farmers are likely to appear profitable, so that prompt repayment can be expected from those farmers who also have good records of fulfilling past obligations.[4]

Guarantees normally are required for bank loans in Costa Rica and might be expected to provide additional assurance of repayment, but bank employees reported that guarantees receive little weight in evaluating loan applications. The reluctance to rely on guarantees

[4] The recognition that credit often may be diverted to uses other than those indicated in the investment plan further reduces the importance of investment plans. Farmers present the projects which they think will be most attractive to bankers, but the credit obtained often is used to finance alternative investments that appear more profitable to farmers. To the extent that alternative investments actually yield higher returns, bankers should not be too displeased because loan repayment prospects are enhanced. Moreover, efforts to prevent credit diversion, such as those criticized by Lipton (especially p. 549), are likely to be both costly and futile.

reflects the costly procedures and political problems that can arise in exercising guarantees to collect overdue loans. The relative costs of exercising different types of guarantees are reflected in the preference of Costa Rican bankers for cosigners and mortgages over cattle rather than mortgages over farms. Cosigners can be as ready as bankers to apply pressure for prompt repayment, while taking away a delinquent borrower's cattle is procedurally and politically far less costly than taking away his farm.

The cost and value of different kinds of information in reducing the risks of delinquency and default not only have resulted in heavy emphasis on prior success in farming and a record of fulfilling past obligations but also have tended to bias the allocation of bank credit away from new crops and new borrowers and toward traditional crops and returning borrowers. Because gathering information about new crops and new borrowers is relatively costly, they are viewed as too risky and consequently receive little bank credit. Traditional crops, on the other hand, are allocated a much larger share of credit than their share of agricultural output would warrant. According to the Ministerio de Agricultura y Ganaderia, just five crops (coffee, rice, sugar, and beef and dairy cattle) accounted for almost 90% of bank agricultural credit disbursed during the 1970–74 period, and coffee and beef cattle alone accounted for about 75%. However, information costs are not necessarily biased against small farmers. Many of them are returning borrowers growing traditional crops, and the innovations discussed above have been particularly effective in reducing the costs of obtaining information about small farmers. Nonetheless, the availability of credit for small farmers, especially if they are new borrowers, should not be overestimated, as the Banco Nacional's rural credit department actually made fewer loans each year in the early 1970s than in the early 1950s (see Gonzalez-Vega, p. 50).

The Costa Rican policy of setting interest rates below equilibrium has been shown to create an excess demand for bank agricultural credit and to necessitate some form of rationing. The structure of these interest rates, together with the foregoing examination of costs, especially information costs, also can explain in the context of profit maximization why Costa Rican bankers have rationed credit to achieve the observed pattern of delinquency rates: lower for agricultural than for nonagricultural loans and lowest on loans to small farmers. For each loan application, bank officials will obtain information about the potential borrower until the cost of this information equals, at the margin, its value in reducing the anticipated risks of delinquency and default. Bank officials can then be viewed as ranking loan applications according to the probability of delinquency and default and allocating available credit by going down the list of potential borrowers from low risk to high risk. If Costa Rican bank officials are competent evaluators, this *ex ante* assessment of risk should be reflected in the delinquency rates achieved *ex post*.

Risks, and hence delinquency rates, will not be equalized for different categories of borrowers to the extent that revenues and costs differ among categories. As indicated above, the Central Bank has set lower interest rates for agricultural loans than for most nonagricultural loans and has reserved the lowest rates for small farmers. Bank officials thus will proceed farther down the list to serve higher-risk applicants in the higher-revenue nonagricultural categories and least far down the list in serving small farmers whose loans produce the lowest revenues. If it is assumed that costs of funds are equal for different categories of borrowers, that fixed costs of processing loans are negligible, and that *ex post* delinquency accurately reflects *ex ante* risks because of efficient information gathering, then interest rates (including commissions) of 8% for small farmers, 10% for other farmers, and 14% for nonagricultural loans imply that nonrepayment rates of 3% for small farmers, 5% for other farmers, and 8% for nonagricultural loans would equalize the expected returns to the bank for the different categories. Such nonrepayment rates would not be inconsistent with the pattern of delinquency rates reported in tables 2 and 3.

Conclusion

The Costa Rican banking system has achieved relatively wide service to the agricultural sector, including small farmers, together with low rates of delinquency and default because of the efficient techniques developed for gathering information about potential borrowers and the profit orientation of bank employees. The system also provides strong incentives for

borrowers to repay promptly, not primarily because of explicit sanctions but rather because of the promise of continuing access to bank credit if repayment is prompt but not otherwise. Continuing access to bank credit is attractive in part because of the below-equilibrium interest rates charged on bank loans. However, below-equilibirum interest rates imply excess demand and hence rationing, and the structure of low interest rates for certain categories of borrowers further implies that these borrowers will be rationed most stringently in their access to bank credit. Such rationing, which tends to offset the benefits for the agricultural sector of innovations in information gathering, is reflected in the pattern of lower delinquency rates for agricultural than for nonagricultural loans with lowest rates on loans to small farmers.

The stated objective of low interest rates on agricultural loans, especially to small farmers, is to promote developmental activities and to benefit disadvantaged borrowers. However, as shown above, these deserving borrowers are in fact more severely limited in access to bank credit than other borrowers. Moreover, low delinquency rates do not provide evidence that bank loans are used to finance productive activities in the agricultural sector. Negative real interest rates, such as existed in Costa Rica for bank agricultural loans in 1973 and 1974, mean that borrowers can undertake projects with negative real rates of return and still generate enough income to repay bank loans. The fungibility of credit, including the limited ability of bankers to control even outright diversion of credit to unprescribed uses, means, furthermore, that agricultural loans may not have financed even unproductive agricultural activities.

If low interest rates in Costa Rica are associated with low rates of delinquency and default, might not a movement to higher interest rates provoke an undesirable increase in delinquency? In part such an increase in delinquency would be desirable as it would reflect incentives for bank officials to lend for riskier projects provided the projects had high expected returns. Higher interest rates also could encourage further innovations in information gathering to evaluate new borrowers and new crops and thereby lessen the concentration of credit in loans to returning borrowers and traditional crops. However, the increase in delinquency would also undoubtedly reflect a reduced incentive for borrowers to repay promptly because maintaining access to bank credit would not be as attractive with higher interest rates. Even this undesirable increase in delinquency might have beneficial aspects if it prompted bank officials to search for other ways to improve service and thereby to increase the attractiveness of bank credit.

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The Political Economy of Agricultural Credit: The Case of Bolivia

Jerry R. Ladman and Ronald L. Tinnermeier

A theoretical framework is established to show that agricultural credit programs in less developed countries can be used for political purposes because of (*a*) government-controlled supply; (*b*) implicit income transfers associated with concessionary interest rates, delinquency, and inflation that can be used as patronage for politically influential borrowers; and (*c*) ease of implementation under guise of economic objectives. The framework is applied to Bolivia. Within that country's political context, large income transfers to a few influential farmers strongly suggest the importance of political factors in credit allocation with consequent effects on income distribution, development, and debilitation of financial institutions.

Key words: agricultural credit, Bolivia, income transfers, political economy, subsidies.

Agricultural credit has been a cornerstone of most agricultural development programs in less developed countries (LDCs). Domestic governments and donors of foreign aid alike have allocated significant sums for agricultural credit programs (Adams). This paper argues that, although such programs are said to be economically oriented, they are susceptible to being used by LDC governments as political tools. Thus, a political economy of agricultural credit emerges in which credit is allocated to satisfy political objectives.

There are five major reasons why the political economy of agricultural credit has become important. First, governments typically control the formal market supply of agricultural credit through development banks and credit policies which force private sector lending to agriculture. Therefore, governments have the ability to influence strongly the distribution and allocation of credit. Second, concessionary interest rate policies, which are almost ubiquitous in LDC agricultural credit programs, provide for an attractive income transfer to borrowers. Third, when governments permit long-term delinquency, a common condition in LDCs, the borrower receives a temporary income transfer for the period of the delinquency. If he never repays, it becomes a permanent transfer. Fourth, when inflation is present, the magnitude of the concessionary and delinquency transfers is magnified. Fifth, the advantages of obtaining these transfers are sufficiently attractive that they can be used by governments to gain patronage of borrowers and, conversely, by borrowers to pledge support to government.

Credit programs are particularly alluring for political purposes. First, they are easy to establish and administer. Second, they are legitimate for economic objectives. Third, because monies are fungible and because of the hidden transfers, the true uses of such funds are difficult to identify. Thus, credit lends itself to being used for political purposes under the guise of economic development.

The extent to which economic decisions are influenced by political factors, or vice versa, is difficult to ascertain in practice. It is becoming increasingly clear, however, that not only is there the potential for political forces to impact heavily on agricultural credit programs, but also they probably play a more important role than has been previously recognized (e.g., see Von Pischke).

This paper first describes the evolution of

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the institutional and policy structure of credit programs in LDCs. The role of foreign aid is emphasized. Second, a framework for the political economy of agricultural credit is specified. Third, the framework is applied to Bolivia, an archetype of underdevelopment where political factors often predominate and where there have been massive infusions of foreign aid for agricultural credit. Fourth, conclusions and policy implications are set forth.

The Evolution of Institutional and Policy Structures

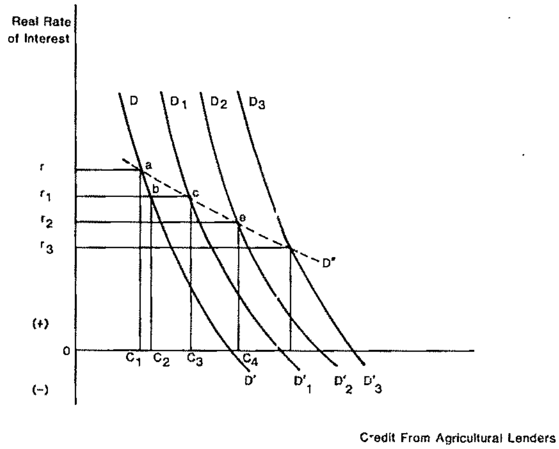
Commercial financial institutions in LDCs have shunned lending to agriculture because of the high costs and risks embodied in these loans (Donald, pp. 27–35). Thus, pressures were placed on government to provide alternative sources of financing. The passivity of the agricultural sector suggested a supply-leading financial approach (Patrick). Government agricultural banks were commonly established. Yet, when it became obvious that government institutions could not meet the needs of financing agriculture, means were sought to force the private sector to lend to agriculture. Central bank rediscount mechanisms, loan guarantees and loan portfolio requirements were common policies.

Almost without exception all of these agricultural credit programs incorporated a feature transferred from the U.S. Farmers Home Administration credit model—the concessionary interest rate; because, from an economic standpoint, it provided elements deemed appropriate to the conditions of LDCs. The concessionary transfer (the income transfer due to the concession) was justified to encourage the use of more highly productive inputs, and to compensate the farmer for the inherent risks in agriculture, the paucity of cost-reducing infrastructure in the countryside, the past injustices done to farmers by moneylenders, and low product prices imposed by the government to protect the interests of urban wage earners (Donald, pp. 101–03). Little attention has been directed heretofore to the tremendous political leverage that the concessionary transfer offers.

A Framework for the Political Economy of Agricultural Credit

Figure 1 presents a country-wide demand curve DD' for credit from agricultural lenders

Figure 1. Demand for credit from agricultural lenders



to be used for agricultural purposes when interest rates are equalized throughout the economy. Assume that the prevailing real interest rate is r; therefore, farmers would want to utilize OC_1 credit. Suppose, however, that the government subsidized agriculture by means of a concessionary interest rate, r_1, for agricultural loans but left interest rates for nonagricultural loans at the previous levels.[1] Two effects would occur. First, borrowers would increase the quantity of funds demanded for agricultural purposes from C_1 to C_2, and, if non-price rationing were not employed, would simultaneously receive a subsidy or income transfer (the concessionary transfer) of r_1rab.

Second, since money is fungible, credit can be borrowed ostensibly for agricultural purposes but diverted to such nonagricultural activities as consumption or investment. This gives rise to agricultural illusion—a situation where some agricultural loans have the appearance of going to that sector, but in fact go elsewhere. With the relatively lower interest rates for agricultural loans, it would be expected that borrowers would behave in this manner—especially those with multiple occupations and knowledge of other investment opportunities—and the demand for credit from agricultural lenders would shift right to $D_1D'_1$. Borrowers would want to use C_2C_3 quantity of credit to practice agricultural illusion and the total concessionary transfer now becomes r_1rac.

[1] The pioneering work on the concessionary interest rates formalized in this paper was done by Adams and Gonzalez-Vega 1976.

If further concessions were granted, e.g., r_2, r_3, etc., there would be yet further demand shifts to the right, such as $D_2D'_2$, $D_3D'_3$. The horizontal distance between any $D_iD'_i$ and DD' at any r_i would represent the amount of credit demanded to practice agricultural illusion due to the concessionary rate. Therefore, the locus of all equilibrium points for all r_i and $D_iD'_i$ traces the illusion demand curve for agricultural credit when concessionary interest rates are employed in that sector. It clearly demonstrates how agricultural illusion increases the concessionary transfer.

Delinquency provides another possibility for an income transfer. A "delinquency transfer" may be temporary, when farmers do not repay their loans on time, or permanent, when they never repay the loan. In the case of the temporary transfer, the farmer gains from improved income or reduced costs resulting from control over cash flow. The permanent transfer is equivalent to the real value of the loan principal plus real value of interest charges less any real amount repaid on loan and interest. In terms of figure 1, the amount of the permanent delinquency transfer would be the OC_3 loan principal plus Or_1cC_3 interest, assuming a concessionary interest rate of r_1, agricultural illusion and no repayment.

When inflation is present, a situation common to LDCs, the real rate of interest may be quite low or even negative. The effect is to enlarge the concessionary transfer and the temporary delinquency transfer (because of the lower real value of the loan when repaid). When inflation is anticipated by farmers, the amount borrowed will increase in accordance with the demand schedule and will further enlarge both transfers. For example, assume a concessionary rate of r_1, but farmers anticipated the real rate of r_2, because of inflation. Borrowers then would gain an additional concessionary transfer caused by inflation of r_2r_1ce and the potential for a permanent delinquency transfer of OC_4 loan principal and Or_2eC_4 interest. The higher the inflation, the greater will be these transfers. In the case of temporary transfers, the longer the delinquency, the greater the transfer.

Clearly the concessionary and delinquency transfers themselves and the additions to these transfers resulting from inflation are to be coveted. Therefore, a government with its control over agricultural credit institutions can use these potential transfers to induce certain types of economic activity and/or to reward certain behavior among borrowers. Moreover, borrowers in their competition for access to, and a share of, the transfer, undoubtedly will be willing to bargain with the government. Thus, there is an interplay between government and farmers in which political factors may take on considerable importance.

Heavy delinquency rates may be symptomatic of the degree that political factors have entered into the loan. When the government does not take the legally available measures to bring pressure on the borrower to repay, this indicates an unwillingness to bear the administrative costs or political consequences of such action.

The sheer existence of the concessionary transfer, and the possibility of an easy delinquency transfer, creates a potential for corruption. Government officials could easily appropriate part of the transfer for themselves by directly or indirectly lending to themselves, or by receiving kickbacks from borrowers.

Consequences

The consequences of using credit as a political instrument will vary depending on the specific situation in any country. It is possible, however, to draw generalizations about expected consequences in four areas: (*a*) resource allocation, (*b*) income distribution, (*c*) institution financial viability, and (*d*) economic development.

Apart from political considerations, the concessionary interest rate policy leads to a nonoptimal social allocation of (*a*) credit, (*b*) other resources, and (*c*) the production of goods in society, unless there is an effective means of non-price rationing. Experience demonstrates, however, that non-price-rationing schemes are difficult to enforce. The schemes are even more unworkable when political factors intervene. If inflation is present, the additional transfer due to inflation enhances the attractiveness of using credit for political objectives. If this occurs the resource allocation consequences are exacerbated. For example, it may encourage speculative investments and inventory stockpiling as well as agricultural illusion.

Access to the concessionary transfer (Gonzalez-Vega, 1977) and the delinquency transfers as a result of borrowing or corruption will gain at the expense of others. Inflationary conditions will increase the benefits of those who receive these transfers. The net result,

under any combination of the several transfers, is that the borrower gains income at the expense of the taxpayer or saver whose money is utilized to provide credit. Moreover, the borrower will gain income relative to those who have no credit or who borrow at true market rates of interest. Where the source is foreign, these effects have international implications as well.

Concessionary interest rates lead to lower interest revenues with the lending institution if the demand for credit is inelastic and/or the supply of loanable funds is restricted over the relevant range of the demand schedule. This, in combination with the well-recognized high costs of administering agricultural credit programs, will seriously jeopardize a credit institution's financial viability. Further, political lending will lead to erosion of loan funds caused by extensive delinquency inherent in such loans. The result is that, to cover costs and maintain or increase its loanable funds, the institution must be subsidized by government or obtain foreign loans or assistance. Without such supports, the institution's financial resources soon would be gone.

Finally, although it is well beyond the scope of this paper to discuss them in detail, it should be noted that there will be additional indirect impacts of credit allocation on general economic development, such as balance of payments, government expenditures and revenues, price stability, rural-urban migration, and sectoral development.

The Role of Foreign Donors

Foreign economic assistance programs contribute to the use of credit as a political instrument in two ways. First, they have provided considerable economic assistance for agricultural credit programs (Adams). Second, they have promulgated the policy of concessionary interest rates with the direct effect of creating concessionary transfers. As a consequence, they have been an indirect contributor to the use of credit for political purposes. This is particularly true for loans which have been made for general agricultural sector development, where credit typically flows to the larger and more sophisticated farmers and agricultural illusion takes on large dimensions. However, even in cases where foreign aid funds are earmarked for small farmers, the additional funds increase the size of the lenders' total portfolio and may permit some substitution for other funds previously directed to small farmers, thus releasing them for other purposes, including political.

Can Interest Rates Be Raised and Defaulting Reduced?

The obvious economic solution to prevent all these distortions is to raise interest rates and decrease default. Why, then, have policies of higher rates not been put into effect? Furthermore, why do not many lenders use their legal powers to limit default? The suggested answer is that the political cost is too great. First, governments would lose attractive elements available to them to bargain for political support. Second, farmers accustomed to the concessionary and/or default transfers would stand to lose substantially. In particular, the impact would fall on the larger and more influential farmers who practice agricultural illusion with access to alternative investment-consumption activities. Third, where corruption occurs, government officials would lose their access to these sources of income.

The Case of Bolivia

The framework is applied to Bolivia during the period of the government of General Hugo Banzer, 1971–78. (For a good discussion of the political developments in Bolivia over this period see Mitchell as well as Malloy and Borzutsky.)

The regional distribution of agricultural credit since 1971 was highly skewed to the tropical lowlands in the department of Santa Cruz. Between 1973 and 1978, 68% of commercial bank loans went to that department (private communication from Banco Central de Bolivia). Between 1971 and 1978, 64% of the volume but only 23% of the number of BAB loans went to Santa Cruz.[2] In contrast, according to the 1976 General Population Census, only 12.6% of the rural population lived in that department. Further, for the period 1964–71, only 43% of Bolivian Agricultural Bank (BAB) credit from regular credit lines went to Santa Cruz.

Several interdependent factors explain the

[2] Data from Departamento de Planificación, Unidad Estadística, from Banco Agrícola de Bolivia. All data reported in the remainder of this paper come from this source unless otherwise indicated.

highly disproportionate share of agricultural credit going to Santa Cruz in the Banzer period. First, the petroleum and agricultural boom in the region was viewed as the leading edge of the Bolivian economy. Rapid gains in food import substitutes and agricultural exports were expected from commercial farms whereas these possibilities were not foreseen for the small-scale traditional farming areas in the highlands. Second, geopolitics was another factor. With the new petroleum development, Bolivia viewed the growth of Santa Cruz as a buffer to further encroachment by Brazil, which had previously taken considerable territory in the rubber boom of 1899.

Whereas both of these factors were important in explaining the disproportionate credit flows, we suggest that domestic political factors were also important in the credit allocation. President Banzer had risen to power in a military coup with the support of a coalition of interests that included farmers in Santa Cruz (Mitchell, pp. 122–3). Hence Banzer was obliged to these persons not only for his sudden rise to power but also for their continued political support.

Institutional and Policy Structure

Over the 1971–78 period, 59% of the banking credit in Bolivia came from BAB. In addition, the government-owned State Bank, a commercial bank, loaned approximately another 20%. The system was amenable to government control. Credit was employed as the major agricultural sector policy instrument to "lead" agricultural production by means of a number of special credit programs established by the government and donors of foreign aid. Key features of credit policy were concessionary interest rates and central bank rediscounts to the banking system from special credit lines for agriculture.

Foreign assistance played a major role by providing a steady inflow of funds which freed government funds for loans to some major enterprises, such as cotton (little foreign assistance was used for this crop), as well as for liquidity which the institutions needed in view of soaring and heavy delinquency. From 1967 to 1978, there were $146 million (all figures in this paper are reported in current U.S. dollars) in foreign assistance committed for agricultural credit. A conservative estimate is that at least 45% of bank credit (BAB and commercial banks) came from this source.

Concentration of Credit

Over the 1971–78 period, BAB loaned $80.9 million in Santa Cruz with 3,348 loans. Of this amount, $45.9 million went to cotton in a total of 726 loans. A much smaller amount, $4.1 million, was directed to 118 farmers for soybeans. The average size loan for cotton and soybeans was $63,169 and $34,525, respectively, much larger than the $5,287 national average. Credit for the two crops, which represented 41% of the national BAB loan portfolio, went to only a few farmers (6% of BAB loans). These loans were made primarily to the larger farmers of Santa Cruz, many of whom belonged to that region's elite and to powerful regional interest groups such as ADEPA (The Cotton Growers Association).

Income Transfers

As shown in table 1, the recipients of BAB cotton and soybean loans received total income transfers of at least $44.5 million over the period, an amount only slightly less than the $49.9 million of principal originally loaned. The average transfers for cotton and soybean loans were $55,000 and $39,000, respectively.

These transfers result in part from interest rate concessions of 12% to 15% for BAB clients relative to the rates charged by commercial banks for commercial loans. Because the commercial rates are maximum rates established by the Central Bank, they are likely to be less than the true opportunity cost of

Table 1. Concessionary and Delinquency Transfers Associated with Cotton and Soybean Loans of Bolivian Agricultural Bank, 1971–1978 (in Thousands of U.S. Dollars)

	Cotton	Soybeans
	thousands	
Loan volume	45,861	4,074
Number of loans	726	118
Average loan size	63	35
Percent past due, 31 Dec. 1978	51	69
Delinquency transfer		
Interest and commissions	3,342	418
Principal	23,491	2,823
Concessionary transfer	5,680	519
Transfers due to inflation	7,399	829
Total transfer	39,912	4,589
Average transfer per loan	55	39

Source: Authors' calculations based on Bolivian Agricultural Bank data.

credit. To the extent this holds true, the concessionary transfer is understated.

The effect of inflation is to reduce the real interest rate and therefore to provide an additional transfer to the borrower. With the exception of 1973 and 1974, inflation in Bolivia was mild, yet the income transfer associated with inflation was substantial, estimated at $8.2 million.

From 1971 to 1978, BAB delinquency worsened. At the end of 1971, 15% of the loan portfolio was overdue; at the end of 1978, it was 43% overdue after reaching a high of 47% in 1977. Had many loans not been refinanced or extended, the situation would have been much worse. During 1978, 776 loans were extended. Furthermore, several BAB loans have been extended many times. The delinquency is concentrated in Santa Cruz: in 1978, 68.8% of the total BAB delinquency was in that department. In Santa Cruz, 48% and 52%, respectively, of loan numbers and volume were past due compared to 27% and 43%, nationally. Both cotton and soybeans contributed to the high proportion of loan volume delinquency.

At the end of 1978, the delinquency transfer associated with cotton and soybeans was $30.1 million. Before June 1977, the government would not permit the BAB authorities to pressure farmers for repayment. Also, to keep some private commercial banks from pressuring farmers, the government issued Supreme Decrees to buy these banks' delinquent portfolios and transfer them to BAB. In June 1977, Banzer issued a Supreme Decree which extended all BAB and State Bank cotton and soybean loans for periods of eight to twelve years. If the loans are paid back as scheduled, the borrowers will pay back virtually nothing in terms of real value due to the depreciating effects of inflation—the equivalent of a permanent income transfer.

The large BAB income transfers for borrowers for the two crops in Santa Cruz cannot be entirely attributed to political factors. Poor client selection, bad weather, insects, and marketing are other reasons. But even in cases of the latter, political intervention led to sizeable transfers. For example, in 1973, BAB and commercial banks financed large quantities of cotton, and ADEPA made forward contracts to sell cotton on the world market. When the world price exceeded the forward price, ADEPA refused to sell. The government supported them as Banzer established a minimum price by Supreme Decree. The world buyers refused to pay this higher-than-contracted price and much cotton remained unsold while delinquency soared.

The case of BAB is illustrative of what also happened in the State Bank. Unfortunately, inadequate data do not permit a breakdown of transfers for credit from that institution. They are, however, sizeable. This institution also began to lend heavily for cotton and soybeans in Santa Cruz after 1972. By 1977, they had discontinued lending to agriculture because of heavy delinquency. In 1978, they had $22.4 million in 232 past-due loans, most of which were for cotton and soybeans. (Private communication from the Banco del Estado.) Clearly, income transfers associated with these loans were also very substantial.

Consequences

The effect of credit being used as a political instrument to benefit the Santa Cruz commercial farming elite undoubtedly contributed to political stability during the Banzer reign. However, the elite's access to credit and the associated income transfers gave them a larger share of national income. Their ability to practice agricultural illusion through investment in real estate, commerce, and conspicuous consumption further enhanced their income and worsened regional and personal income distribution. For example the highland peasants gained little, and if it had not been for foreign aid for small farmer credit, which began in 1975, it is doubtful that this large mass of farmers would have received much credit at all. It is plausible that such inequities were important factors in the defeat of the government's candidate in the 1978 elections.

The long-run viability of financial institutions was seriously harmed. After 1976, the State Bank withdrew from agricultural lending because of the high costs associated with its heavy delinquency. In March 1979, BAB had to be rescued from bankruptcy by the government when it issued $41.5 million in bonds (El Diario) which permitted BAB to meet its financial obligations.

Conclusions

It should not be surprising that government-controlled credit institutions and policy can be used for political objectives although they are

cast in the context of economics. Credit as a political instrument is attractive to a government because it is rapidly implementable and has the appearance of going for worthwhile economic objectives but in reality offers opportunities for considerable benefits to borrowers by means of income transfers and gains from fungibility. Moreover, because the true benefits are hard to identify, they are less subject to the scrutiny of the opposition and the general public.

The usefulness of the present study is to provide a theoretical framework to show the use of agricultural credit as a political-economic instrument particularly where concessionary interest rates and permissive default are employed. The Bolivian case clearly illustrates the political economy of credit as it was applied by Banzer in 1971 to 1978. It also shows the unintended role of foreign assistance in abetting the use of credit in a political context.

The Bolivian case is not unique. It is likely that political forces figure strongly in credit allocation decisions in most nations. While they may contribute to political stability, they are subject to abuse and have undesirable consequences for resource allocation, income distribution, and financial institution viability. The degree to which credit can be used as a political instrument would be substantially reduced if concessionary interest rates were eliminated, a tougher stance on default were taken, and inflation reduced.

The voluntary implementation of the required interest rate and default policies will be difficult to attain given the high costs to governments in the loss of a political instrument. Therefore, pressures will have to be exerted by foreign donors in an appeal to improve resource allocation, income distribution, and financial institution viability.

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Market Intervention Policies for Increasing the Consumption of Nutrients by Low Income Households

Richard K. Perrin and Grant M. Scobie

There is an immense step in passing from theory to governmental applications . . . and if this essay is of any practical value, it will be chiefly in making clear how far we are from being able to solve, with full knowledge of the case, a multitude of questions which are boldly decided every day.
—Augustin Cournot, 1838

This study employs a market equilibrium displacement approach to examine the nutrient consumption effects of market intervention programs such as food subsidies, income transfers, and agricultural input subsidies. The results permit comparison of the direct treasury costs of achieving marginal increases in nutrient intake with alternative programs. When applied to a case study of the food markets and population of Cali, Colombia, it was found that a marginal increase in caloric intake among the poor could be achieved at lowest cost with a consumer subsidy of certain cereals, although black market activity might raise this cost to that of an income subsidy.

Key words: Colombia, food policies, nutrient consumption, treasury costs.

Throughout much of the postwar period, the objectives of development were expressed in terms of economic growth. Through rapidly rising national products, real income gains were expected to accrue (albeit with the same lag) to an increasingly wider spectrum of the population. Gradually, marginal participants would be drawn into the mainstream of economic activity with part of the increments in real income being spent on additional food. In short, policies which stimulated overall economic growth were seen to be conducive to generally rising living standards including increased nutrient intake. Few if any countries had explicitly formulated, or funded, national nutrition programs.

Whether through disillusionment or impatience with the previous strategies, development objectives have been evolving which are much more narrowly focused (Selowsky 1979). The direct provision of food, education, health services, sanitation, and housing have become part of the "basic human needs" approach to aid and development. Governments have sought instruments with which they can effect changes directly in some specific target. Improved human nutrition is one such target (Scandizzo and Knudsen).

Economic research has been directed to measuring the magnitude of the malnutrition problem (Reutlinger and Selowsky) and its impact on physical, intellectual, and economic development (Selowsky 1978, Selowsky and Taylor). Other research has explored the possibilities for achieving nutrition goals through such government interventions as food price subsidies for the poor (Reutlinger and Selowsky; Ahmed; Kumar; George), income transfers to the poor (Pinstrup-Andersen and Caicedo), agronomic research (Pinstrup-Andersen, Ruiz de Londoño and Hoover), and agricultural production subsidies (Barker and Hayami; Hayami, Bennegan, Barker).

The purpose of the research reported here is to examine and compare the treasury costs of achieving specified nutritional goals through

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alternative intervention programs such as those above, both in general and in a specific case study of consumers in Cali, Colombia. Given the magnitude of current intervention efforts in various countries,[1] such a comparison may prove to be quite valuable in assessing the impact of alternative policies.

Analytical Model

To permit comparison of the wide variety of intervention policies available, we find it convenient to group them into three categories: those which shift supply to the right, those which shift demand to the right, and those which drive a subsidy or wedge between producers' price and consumers' price. Figure 1 illustrates, for example, how an increase in food consumption from Q to Q' could be achieved either by a supply shift from S to S', by a demand shift from D to D', or by a market wedge of size W under which producers would receive price P'_1 while consumers would pay price P'_2. While not all possible market intervention policies can be directly represented by this analytical framework (such as certain types of food stamp programs), a great many can be. For example, supply shifting interventions can include (*a*) public investment in agricultural research which generates new information and technologies, (*b*) public investment in rural infrastructure, (*c*) direct subsidies of agricultural inputs, and (*d*) food import policies. Policies which shift demand can include (*a*) direct income transfers, (*b*) certain types of food stamp programs, or (*c*) nutrition-oriented consumer education programs. The price wedge approach can be used to describe a number of kinds of subsidy mechanisms, such as simple food stamp plans, ration shops, and bounties paid to producers.

To complete the analytical framework necessary to compare these policies, we first develop a model describing the price and quantity equilibrium displacement effects of each of the three basic types of policy instruments, for an n-commodity food economy with a malnourished ("poor") consuming sector and an adequately nourished ("rich") consuming sector. Given the nutrient content of these commodities,[2] the effect of the policies on equilibrium nutrient intake follows directly. We then examine in more detail the effect of income transfers and price wedges in order to compare their cost effectiveness in terms of the treasury costs associated with increments in nutritional improvement. In this paper we do not address issues related to the financing of such interventions, nor do we consider the potential effect of these public financing activities on food markets.

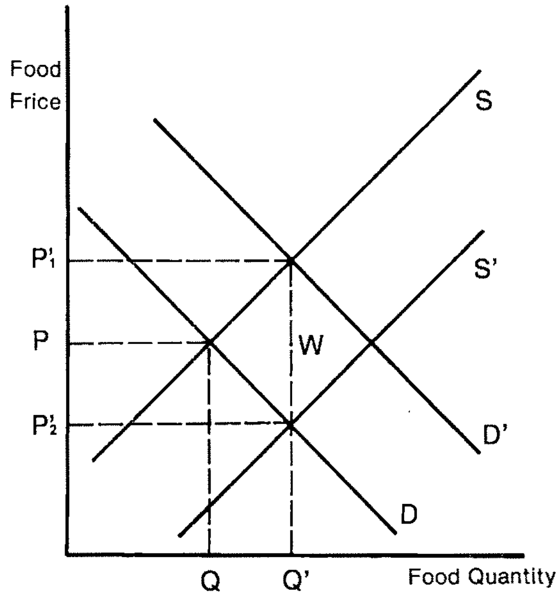

Figure 1. Increase food consumption via a supply shift, a demand shift, or a market wedge

Equilibrium Displacements Caused by Shifts in Demand, Supply, or Market Wedges

First consider the n-demand curves for the consuming population as a whole (we later stratify consumers into rich and poor strata). Changes from initial equilibrium levels of consumption of commodity i must result from either a shift in demand for that commodity or from a change in the price of either commodity i or one of the other commodities. The percentage change in quantities demanded can conveniently be expressed as

$$(1) \qquad Eq_i = \sum_{j=1}^{n} \eta_{ij} Ep_j^d + \gamma_i Ey,$$

where $i = 1, \ldots, n$; E is the percentage

[1] Subsidies on staple foods constitute a substantial proportion of total expenditures by some governments. "In Egypt, Korea, and Sri Lanka, food subsidies accounted for as much as one-fifth of total expenditure in 1974 or 1975, while several other countries devoted approximately one-tenth of expenditure to this component" (Davis). From a study of Egyptian food subsidies, Taylor (p. 35) reports that in 1975, staple food subsidies (on wheat, maize, sugar and edible oil) amounted to over 11% of gross domestic product.

[2] In this study, we consider only calorie consumption as a measure of nutrition, because of its importance as a limiting nutrient (Reutlinger and Selowsky). The equilibrium displacement model could quite easily be extended to consider a vector of several nutrients.

change operator,[3] η_{ij} are the direct and cross-price elasticities of demand, γ_i is the income elasticity of demand, and y denotes income. The effect of food stamp or nutritional education programs could be represented by a reinterpretation of the demand shifter ($\gamma_i Ey$).

Supply changes can be represented as

$$(2) \qquad Eq_i = \sum_{j=1}^{n} \epsilon_{ij} Ep_j^s + \delta_i,$$

where $i = 1, \ldots, n$; ϵ_{ij} are supply elasticities and δ_i is a supply shift caused by some policy. Such policies might include input subsidies (as in Barker and Hayami) or investment in agricultural research (as in Pinstrup-Andersen, de Londoño, Hoover). In work not reported here, we have used the model that follows to derive analytical solutions comparable to both these studies.

To incorporate the possibility of price subsidies, we specify the following equilibrium relationship between supply prices and demand prices:

$$(3) \qquad Ep_i^s = Ep_i^d + E\beta_i,$$

where $i = 1, \ldots, n$; $E\beta_i$ is the size of the subsidy wedge for commodity i, measured as a percentage of initial equilibrium price. These three sets of n equations each can be expressed in matrix notation as

$$(4) \qquad \begin{bmatrix} -H & 0 & I \\ 0 & -S & I \\ -I & I & 0 \end{bmatrix} \begin{bmatrix} EP^d \\ EP^s \\ EQ \end{bmatrix} = \begin{bmatrix} \Gamma Ey \\ \Delta \\ EB \end{bmatrix},$$

where H is an $n \times n$ matrix of demand elasticities, η_{ij}; S is an $n \times n$ matrix of supply elasticities, ϵ_{ij}; P^d is an $n \times 1$ vector of demand where P_p^d, P_r^d are $n \times 1$ vectors of demand prices by stratum; Q_p, Q_r are $n \times 1$ vectors of quantities by stratum; V_p, V_r are $n \times n$ diagonal matrices with the share of the com- prices, p_i^d; P^s is an $n \times 1$ vector of supply prices, p_i^s; Q is an $n \times 1$ vector of quantities, q_i; Γ is an $n \times 1$ vector of income elasticities of demand, γ_i; Δ is an $n \times 1$ vector of supply shifts, δ_i; and EB is an $n \times 1$ vector of price subsidies, $E\beta_i$.

The solution to the system of equations (4) expresses changes in equilibrium prices and quantities as functions of the policy variables, Ey, Δ and EB:

$$(5) \qquad \begin{bmatrix} EP^d \\ EP^s \\ EQ \end{bmatrix} = \begin{bmatrix} (S - H)^{-1}(\Gamma Ey - \Delta - SEB) \\ (S - H)^{-1}(\Gamma Ey - \Delta - HEB) \\ H(S - H)^{-1}(SH^{-1}\Gamma Ey - \Delta \\ \quad - SEB) \end{bmatrix}$$

Given these changes in the equilibrium consumption of commodities, the percentage change in the equilibrium level of nutrient consumption (calories in our case) is

$$(6) \qquad EC = KEQ = KH(S - H)^{-1} (SH^{-1}\Gamma Ey - \Delta - SEB),$$

where K is a $1 \times n$ vector of k_i, the fraction of initial total calorie consumption provided by commodity i.[4]

We have now established the functional relationship between the policy variables and the target variable (nutrient intake) for the simple case in which demand shifts (ΓEy) and price subsidies (EB) apply to the entire consuming population. But income transfers and price subsidies often will apply to only a subset of the population, so we must stratify the demand equations. Equation (1) is replaced by separate demand equations for the poor and the rich strata. The solution to this expanded system of equations,[5] which can be derived in a manner analogous to (5), is

$$(5a) \qquad \begin{bmatrix} EP_p^d \\ \\ EP_r^d \\ \\ EP^s \\ \\ EQ_p \\ \\ EQ_r \\ \\ \end{bmatrix} = \begin{bmatrix} (S - H)^{-1}[V_p\Gamma_p Ey_p + V_r\Gamma_r Ey_r - \Delta - \\ (S - V_rH_r)EB_p - V_rH_rEB_r] \\ (S - H)^{-1}[V_p\Gamma_p Ey_p + V_r\Gamma_r Ey_r \\ - \Delta - V_pH_pEB_p - (S - V_pH_p)EB_r] \\ (S - H)^{-1}(V_p\Gamma_p Ey_p + V_r\Gamma_r Ey_r \\ - \Delta - V_pH_pEB_p - V_rH_rEB_r) \\ H_p(S - H)^{-1}[(S - V_rH_r)H^{-1}\Gamma_p Ey_p \\ + V_r\Gamma_r Ey_r - \Delta - (S - V_rH_r)EB_p - V_rH_rEB_r] \\ H_r(S - H)^{-1}[(V_p\Gamma_p Ey_p + (S - V_pH_p) \\ H_r^{-1}\Gamma_r Ey_r - \Delta - V_pH_pEB_p - (S - V_pH_p)EB_r] \end{bmatrix},$$

[3] The percentage change in a variable x, represented as $E(x)$, can be defined as $E(x) = d\ln(x) = dx/x$.

[4] Note that the results of the solutions (5) and (6) can be interpreted as point elasticities. Equation (6), for example, expresses the percentage change in equilibrium calorie consumption as a linear function of, say, δ_i, which is the percentage shift in the supply of commodity i. The slope $dEC/d\delta$ is the point elasticity of the effect of δ_i on EC, which will be correct only to a first-order linear approximation for any noninfinitesimal δ_i.

[5] The derivation of this solution can be obtained from the authors.

modity consumed by the stratum displayed or the diagonal, v_{pi} and v_{ri}. Also, H_p, H_r are $n \times n$ demand elasticity matrices by stratum; H is defined as $V_pH_p + V_rH_r$; Γ_p, Γ_r are $n \times 1$ vectors of income elasticities by stratum; Ey_p, Ey_r are percentage changes in income by stratum; EB_p, EB_r are $n \times 1$ vectors of price subsidies by stratum.

The percentage change in the equilibrium level of calorie consumption in the poor stratum is then

$$\text{(6a)}\quad EC_p = K_pEQ_p = K_pH_p(S - H)^{-1} [(S - V_rH_r)H_p^{-1}\Gamma_pEy_p + V_r\Gamma_rEy_r - \Delta - (S - V_rH_r)EB_p - V_rH_rEB_r],$$

where K_p is the $1 \times n$ vector of calorie consumption weights in the poor sector.

Treasury Costs of Achieving Consumption with Income Transfers

Direct income transfers to the poor sector will shift the demand for each commodity (by the poor sector) outward by the proportion γ_iEy_p. The net equilibrium nutritional impact of an income transfer to the poor, EC_p/Ey_p, we will refer to as the total income elasticity of calorie consumption. From (6a), the total income elasticity of calorie consumption by the poor is

$$\text{(7)}\quad \frac{EC_p}{Ey_p} = K_pH_p(S - H)^{-1}(S - V_rH_r)H_p^{-1}\Gamma_p = -K_pZH_p^{-1}\Gamma_p$$

where $Z \equiv -H_p(S - H)^{-1}(S - V_rH_r) = -H_p [I - (S - V_rH_r)^{-1}V_pH_p]^{-1}$.

Intuitively, this elasticity will consist of two parts, the first being the direct consumption effect of increased incomes among the poor, which Reutlinger and Selowsky refer to as income elasticity of demand for calories. The second part will be a dampening effect on consumption, resulting from price increases as the market system adjusts to the higher demand for food by the poor.

The first part, the income elasticity of demand for calories, can be determined as a special case of (7) in which the elements of S approach infinity, i.e., perfectly elastic supplies. In this special case, $Z = -H_p$, and the income elasticity of demand for calories is, thus,

$$\text{(7a)}\quad \frac{EC_p}{Ey_p} = K_p\Gamma_p = \sum_{i=1}^{n} k_{pi}\gamma_{pi}.$$

Thus the income elasticity of demand for calories is just the weighted sum of income elasticities of demand for commodities, with the weights being the proportion of the poor's calories provided by that commodity. This is the result obtained by Pinstrup-Andersen and Caicedo (p. 403).

The other limiting case of interest is that for perfectly inelastic supplies, $S = 0$, in which case any extra food consumption by the poor can only be obtained by reduced consumption among the rich. In this case,

$$Z = -H_p[I + (V_rH_r)^{-1}V_pH_p]^{-1} = -[I + H_p^{-1}(V_rH_r)^{-1}V_p]^{-1}H_p,$$

so (7) can be written as

$$\text{(7b)}\quad \frac{EC_p}{Ey_p} = K_p[I + H_p(V_rH_r)^{-1}V_p]^{-1}\Gamma_p.$$

This is the analytical solution for the results obtained by Pinstrup-Andersen and Caicedo [eq. (7), p. 405].

In measuring costs, we shall, for the purposes of this paper, ignore administrative costs and any social costs in terms of welfare triangles or other measures. The direct treasury costs of an income transfer Ey_p will of course depend upon the initial per capita income of the poor, y_p, and the number of poor persons. The treasury cost on a per-poor-person basis is simply

$$\text{(8)}\quad Gy = y_pEy_p,$$

or, given the relationship between Ey_p and calorie gain in equation (7), per person treasury costs can be expressed directly as a function of calorie gains EC:

$$\text{(9)}\quad Gy = y_p(k_pZH_p^{-1})^{-1}EC_p.$$

Note that this is a linear relationship, i.e., an additional 1% increase in calorie consumption can be achieved at constant cost in terms of the fraction of current income required as an income transfer.

Treasury Costs of Achieving Consumption with Food Price Subsidies

We derived, in equation (6a), the nutritional impact of food subsidies offered only to the poor consumer stratum. Before we examine the treasury costs of such policies, we should point out that the results of equation (6a) will hold only if the poor do not take advantage of the arbitrage opportunity to purchase food at the subsidized price and sell it to the rich con-

sumer sector via a black market.[6] If such arbitrage were costless and if it occurred freely, the rich would tend not to buy any food on the open market, but instead would pay the black market price. The effect would then be for the entire consumer market demand to be channeled through the poor, so that the government in effect would subsidize the entire consumer sector, with results described by equation (6) rather than (6a).[7] Now, since arbitrage cannot be costless, one could not expect complete arbitrage to occur; but neither would one anticipate a total absence of arbitrage, as is implied by the results of equation (6a). While it would be of interest to describe more fully the equilibrium results as a function of the costs of or the extent of arbitrage, we have not done so. Instead, we will simply describe the results of the two extreme cases—a general subsidy to all consumers versus a subsidy only to the poor in which no arbitrage takes place.

The treasury cost of general (i.e., for all consumers) price subsidies is equal to the amount of each subsidy, $p_iE\beta_i$, times final quantity, $q_i(1 + Eq_i)$, or

$$(10) \quad G_B = \Sigma p_i q_i E\beta_i(1 + Eq_i) = \Sigma p_i q_i E\beta_i + \Sigma p_i q_i E\beta_i Eq_i,$$

or, in matrix notation,

$$(10a) \qquad G_B = EB'R\lambda + EB'REQ,$$

where R is the $n \times n$ diagonal matrix with the diagonal elements consisting of initial expenditures (p_iq_i) on the ith commodity, and λ is an $n \times 1$ vector of 1's. The change in quantities EQ, resulting from price wedges EB, is obtained from equation (5) and is substituted into (10a) to yield the cost equation

$$(11) \quad G_B = EB'R\lambda - EB'RH(S - H)^{-1}SEB.$$

By similar derivations, the treasury cost of a subsidy only to the poor sector can be expressed as

$$(12) \quad G_{Bp} = EB'_pR_p\lambda + EB'_pR_pZEB_p,$$

where R_p is the $n \times n$ diagonal matrix of food expenditures by the poor.

[6] Ahmed (p. 40) cites evidence of such arbitrage under the dual price system for rice in Bangladesh.

[7] This assumes that the government makes available any quantity that is demanded at the subsidized price. In Bangladesh, allotments of subsidized grain sometimes exceed household consumption (Ahmed, p. 40).

Now it is not possible to establish a direct one-to-one relationship between the treasury costs of subsidies and calorie gains achieved, because there are many values of the subsidy vector EB which could achieve a given calorie gain [see eq. (6a)]. One might naturally be interested in that subsidy vector EB which achieves a given calorie gain at lowest treasury costs, but we do not pursue that issue here. However, there will be a one-to-one relationship between treasury cost and calorie gain if the subsidy is uniform for all foods or for a subset of food commodities. In this case, the vector of subsidies can be represented as $EB = \pi E\beta$, where π is a vector consisting of zeros for commodities not subsidized and ones for commodities subsidized, and where $E\beta$ is a scalar representing the size of the uniform subsidy.

First consider a uniform subsidy for all consumers. The treasury cost as a function of the subsidy is

$$(13) \quad G_\beta = E\beta\pi'R\lambda - \pi'RH(S - H)^{-1}S\pi E\beta^2.$$

Solve equation (6) for $E\beta$ and substitute into (13) to obtain treasury costs as a quadratic function of calorie gains:

$$(14) \quad G_\beta = \{-\pi'R\lambda[K_pH_p(S - H)^{-1}S\pi]^{-1}EC_p - \{\pi'RH(S - H)^{-1}S\pi[K_pH_p(S - H)^{-1}S\pi]^{-2}\} EC_p^2.$$

By a similar derivation, the cost of calorie gains with a uniform subsidy for the poor sector only can be derived as

$$(15) \quad G_{\beta p} = [\pi'R_p\lambda(K_pZ\pi)^{-1}]EC_p + [\pi'R_pZ\pi(K_pZ\pi)^{-2}]EC_p^2.$$

A special case of uniform subsidies of some interest is the subsidy of a single commodity i, which was examined in some detail by Reutlinger and Selowsky. If the supply and demand elasticity matrices are diagonal, as they assume, equation (15) can be reduced to an expression in terms of own-price elasticities as

$$(16) \quad G_{\beta i} = \frac{p_iq_i}{-k_{pi}\eta_{pii}}\left(1 - \frac{\eta_{ii}}{\epsilon_{ii}}\right)\left(EC_p + \frac{\eta_{ii}}{k_{pi}\eta_{pii}}EC_p^2\right).$$

This is exactly the result obtained and used by Reutlinger and Selowsky [eq. (25), p. 45]. Similarly, the cost of a "poor-only," single-

commodity subsidy with diagonal supply and demand elasticity matrices can be derived from (16) as

$$(17)\quad G_{\beta pi} = \frac{p_i q_{pi}}{-k_{pi}\eta_{pii}}\left[\left(1 - \frac{v_{pi}\eta_{pii}}{\epsilon - v_{ri}\eta_{pii}}\right) EC_p + \frac{1}{k_{pi}} EC_p^2\right].$$

The linear terms of either (16) or (17) indicate the relative marginal costs of achieving the first marginal units of calorie gains from subsidizing the commodity.

A Colombian Case Study

In this section the analytical model is used to examine potential intervention policies for the city of Cali, Colombia. Specifically, we wish to compare the cost effectiveness of an income transfer versus certain food subsidy schemes, for raising calorie consumption among the malnourished.

The general characteristics of the sample population are described by Pinstrup-Andersen, de Londoño, and Hoover (1976, table 1). They grouped the sample into five income strata. The lowest income group (with annual per capita income of \$60) we designate as poor (p). Their actual calorie intake of 1,904 calories per capita would have to increase by 12.36% to attain the recommended daily allowance (RDA) of 2,140 calories. The remaining four income categories we group together under the heading "rich" (r), because in each the average per capita calorie consumption approximately equals or exceeds the RDA. The annual per capita income of the lowest of these four strata is but \$107 (1970 dollars), which should serve to caution us from inferring more from these labels than calorie sufficiency.

We will use the results of the analytical model to examine the treasury costs of increasing the calorie intake of the poor both at the margin and by amounts up to 12.36%. In the study of this population, twenty-two food commodities were identified, as listed in table 1. The demand elasticity matrices as estimated by Pinstrup-Andersen for each of the strata were made available to us, permitting us to construct H_p and H_r corresponding to the poor and rich groups. No information about S, the supply elasticity matrix, was available, so we

Table 1. Characteristics of Foods

Commodity	Price (Pesos/Kg.)	Income Elasticity of Demand (Poor)	Own-Price Elasticity of Demand (Poor)	Budget Share (Poor)	Caloric Density (Cals./Gm.)	Caloric Share (Poor)
1. Beef	15.0	1.5	−1.5	0.11	2.3	0.03
2. Pork	14.7	2.0	−1.9	0.03	2.5	0.01
3. Eggs	8.9	1.4	−1.3	0.03	0.9	0.01
4. Milk	2.5	1.6	−1.8	0.03	0.6	0.02
5. Rice	3.7	0.4	−0.4	0.08	3.6	0.16
6. Maize	2.1	0.6	−0.6	0.05	3.2	0.15
7. Beans	8.4	0.8	−0.8	0.04	3.0	0.03
8. Lentils	12.8	0.9	−0.9	0.01	3.2	0.01
9. Peas	13.3	1.1	−1.1	0.01	0.4	0.00
10. Other grains	4.1	0.9	−0.9	0.05	3.4	0.08
11. Potatoes	2.1	0.4	−0.4	0.04	0.9	0.04
12. Cassava	1.6	0.2	−0.2	0.04	1.5	0.08
13. Vegetables	2.6	1.1	−1.1	0.05	0.2	0.01
14. Tomatoes	5.7	1.2	−1.2	0.05	0.2	0.00
15. Plantain	1.8	0.3	−0.5	0.05	1.4	0.08
16. Oranges	1.4	1.1	−1.4	0.03	0.3	0.01
17. Other fruits	5.0	1.3	−1.3	0.03	0.3	0.00
18. Bread and pastry	6.6	0.6	−0.7	0.03	3.5	0.03
19. Butter and margarine	16.0	2.4	−2.8	0.01	7.3	0.01
20. Sugar	2.8	0.3	−0.3	0.05	3.8	0.15
21. Oils and fats	9.5	0.8	−0.8	0.04	8.7	0.07
22. Processed food	14.3	1.9	−1.9	0.02	4.0	0.01

Source: Per Pinstrup-Andersen (personal communication).

have assumed it to be diagonal, with all elasticities equal. We examined results, using elasticity values of 0, 0.5, 1.0, and 2.0. As the results did not differ greatly, we present here only those results for the values of 0.0 and 1.0 for all supply elasticities.

The results presented in table 2 show that, except for the maize price subsidy (which is lowest in cost), the uniform subsidy of "all grain" provides the least-cost marginal increase in calorie consumption, followed by subsidies of other individual commodities and all foods together, the direct income transfer, and the general food subsidy for all persons, in that order. The results are not very sensitive to supply elasticity, since the poor stratum is in this case quite a small proportion of the population, and prices are not therefore greatly affected.

The cost per increase in calorie consumption attained with price subsidies rises with the amount of the calorie increase realized, because the cost functions [eqs. (12), (14), and (15)] are quadratic. As is evident from the plots of some of these costs functions in figure 2, however, the quadratic term does not cause a significant departure from linearity over the relevant range of calorie consumption increases. A more serious approximation error over this range arises from nonlinearity in the demand curves as the size of the subsidy increases. Our model utilizes point estimates of the elasticity of demand and generates point estimates of the elasticity of equilibrium displacement. As we examine finite equilibrium displacements, the model approximates changes in quantity demanded as $Eq = \eta Ep^d$ effectively by a linear demand curve over which η holds as an arc elasticity. The model itself provides no sensitivity analysis which permits us to determine the size of the errors introduced by departures of the demand curves from linearity. However, we have examined the subsidy limit at which the demand curves cross the horizontal axis, as an indication of where the estimates certainly become unrealistic. In the case of a maize price subsidy with unit supply elasticities, this limit occurs with a calorie increase of about $EC_p = .10$. That is, with linear demand curves exhibiting arc elasticities as shown in table 1, calorie consumption among the poor can be increased only about 10% if the maize is given away to the poor stratum. The comparable limits for subsidies of other commodities are even smaller. We conclude from this that our model does not accurately predict the equilibrium displacements from single commodity subsidies except for small increases in calorie consumption, say in the vicinity of 1% or 2%.

By contrast, the uniform subsidy of all grains (maize, rice, and other grains) requires a price reduction to the poor of "only" about 45% to achieve the full 12% increase in calorie consumption, and the uniform subsidy on all twenty-two commodities requires a price re-

Table 2. Annual Treasury Costs per Poor Person for Increased Calorie Consumption among the Poor

Type of Intervention	Supply Elasticities = 0	Supply Elasticities = 1.0
	($ 1970)	
Direct income transfer to the poor[a]	$1.17\ EC_p$	$1.00\ EC_p$
Price subsidy to the poor for individual commodities[b]		
Beef	$2.92\ EC_p + 174.81\ EC_p^2$	$3.44\ EC_p + 258.26\ EC_p^2$
Rice	$.58\ EC_p + 2.46\ EC_p^2$	$.52\ EC_p + 2.29\ EC_p^2$
Maize	$.36\ EC_p + 2.21\ EC_p^2$	$.29\ EC_p + 1.75\ EC_p^2$
Other grains	$.56\ EC_p + 6.32\ EC_p^2$	$.41\ EC_p + 4.70\ EC_p^2$
Potatoes	$1.10\ EC_p + 15.81\ EC_p^2$	$.84\ EC_p + 11.98\ EC_p^2$
Cassava	$.94\ EC_p + 6.09\ EC_p^2$	$.70\ EC_p + 4.38\ EC_p^2$
Sugar	$.59\ EC_p + 2.80\ EC_p^2$	$.47\ EC_p + 2.20\ EC_p^2$
Uniform price subsidy to the poor for several commodities[c]		
All grains (maize, rice and other grains)	$.50\ EC_p + 1.00\ EC_p^2$	$.40\ EC_p + .92\ EC_p^2$
All food	$.97\ EC_p + 1.50\ EC_p^2$	$.83\ EC_p + 1.22\ EC_p^2$
Uniform price subsidy all food, all people[d]	— —	$9.32\ EC_p + 6.07\ EC_p^2$

[a] Calculated using equation (9).
[b] Calculated using equation (15).
[c] Calculated using equation (15).
[d] Calculated using equation (14).

duction of less than 20% to achieve that increase in consumption. Hence, approximation errors due to nonlinearity of demand and supply curves will be substantially smaller for subsidies of groups of commodities. Even so, this model is best suited to the prediction of equilibrium displacement from relatively small interventions in the market.

Recall that the predicted nutritional impact of these price subsidies to the poor would occur only if there were no arbitrage sales of subsidized food by the poor to the rich. We earlier argued that in the limiting case of complete and costless arbitrage, where all food purchases are channeled through the poor, the treasury costs and calorie gains would be the same as in the case of general price subsidy to the entire population. With a general uniform subsidy, the cost of achieving nutritional gain in the poor stratum would increase dramatically. The cost to achieve a given calorie target is about ten times the cost required for a "poor-only" subsidy for which arbitrage could be excluded. Figure 2 provides some indication of this dramatic increase.

To provide estimates to compare with other studies, we have used equation (7a) to determine that the income elasticity of demand for calories within the poor stratum is 0.63. Given unit supply elasticities, however, price increases would dampen this direct income effect, so that the total income elasticity of calorie consumption is [from eq. (7)] slightly lower, 0.60. For zero supply elasticities, the estimate falls further to 0.51. (This compares to an estimate of 0.54 implied by table 5 in Pinstrup-Andersen and Caicedo, which they derived from an iterative equilibration analysis of the same data). The price-dampening effect on income elasticity is small in this case study because the poor stratum comprises only 18% of the population, and their increased purchasing power has a modest effect on prices. Our estimate of 0.63 for income elasticity of demand for calories compares favorably with Ahmed's estimates of calorie expenditure elasticity among the poor of Bangladesh (0.5 to 1.37 for various strata within the poor). However, it is considerably higher than the estimate of 0.19 given by Reutlinger and Selowsky (p. 72) for all of Latin America. Their estimates apply to consumers as a whole, rather than just to the poor strata, and they based their estimates on national aggregate consumption data rather than on household data.

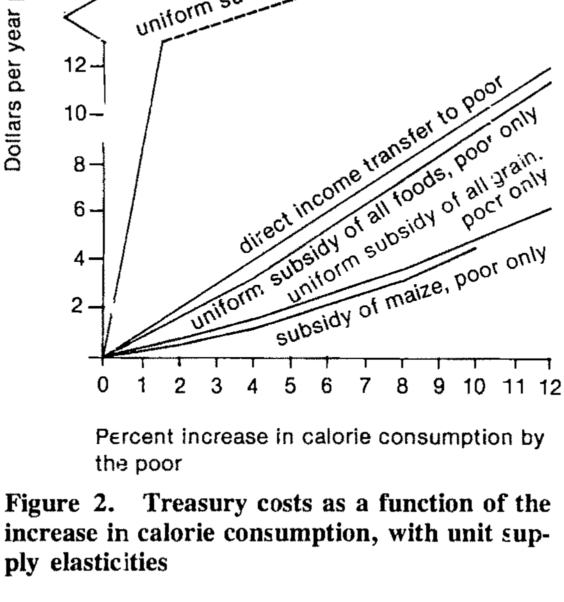

Figure 2. Treasury costs as a function of the increase in calorie consumption, with unit supply elasticities

Summarizing the results of this case study, it appears that the lowest-cost-feasible policy to achieve substantial increases in calorie consumption would be a price subsidy on grains, at an annual cost of about $.40 per poor person for each 1% increase in calorie consumption. A price subsidy for all foods for the poor could achieve the same results for about $.83 per person. However, arbitrage sales from the poor to the rich would raise the costs of such price subsidy programs; and it is quite possible that even with modest levels of black market activity, the cost of achieving the calorie target with price subsidies could exceed the $1.00 annual cost per person for achieving each 1% gain using a direct income transfer.

Summary and Conclusions

We have developed an analytical model of equilibrium displacement with which the effects of a wide variety of food market intervention policies can be evaluated and compared. This model derives point elasticities of nutrient consumption in response to market wedges or to shifters of demand and supply.

These elasticities are then used to determine treasury costs as a function of increases in nutrient consumption, for various intervention policies.

We used the results of this model to examine the case of consumers in Cali, Colombia. Information was available by income stratum on demand elasticities and food expenditures, together with data on the caloric content and prices of twenty-two food commodities. For the poorest income stratum (the only one for which average per capita caloric consumption was below the target level of 2,140 calories per day), we calculated the income elasticity of demand for calories to be .63, and the total income elasticity of calorie consumption (including equilibrium price adjustment effects) to be .60. Including these price adjustment effects, we determined that to achieve each 1% increase in calorie consumption, the required annual per capita income subsidy would be about $1.00.

We found that a 1% increase in calorie consumption could be obtained with a price subsidy on all commodities for the poor at a treasury cost of about $.83 per person per year, which is slightly less than the cost of the income subsidy approach. It would be even less expensive to achieve marginal consumption increases by subsidizing certain commodities or groups of commodities, rather than to subsidize all food commodities equally. For example, a subsidy of the price of grains (rice, maize, and "other grains") would achieve a 1% consumption increase at an annual cost of only $.40 per person. The cost of any of these price subsidy schemes will be increased to the extent that black markets funnel subsidized goods through the poor sector into the rich sector.

In addition to the limitations of our model imposed by its linearity, there are other limitations of this approach which should not be overlooked. We have examined only the direct treasury costs of these intervention policies, ignoring administrative costs and social cost triangles or other measures of social welfare. We have ignored the issue of where government funds for intervention might be obtained and the impact that such fundraising itself would have on food markets. Finally, we have taken the noneconomic goal of increased calorie consumption as a given. The validity of this as a goal, versus simply an increase in real income as a goal, is certainly an issue for debate. Furthermore, increased calorie consumption may not be the best route to improved health status among the poor, given such alternatives as medical care, improved sanitation, or nutrition-oriented education of household decision makers (Franklin and Vial). However the approach of this study does provide some new insights and perspectives for examining the efficiency and costs of policies oriented toward increasing nutrient consumption in low income households.

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Farm Level Economics of Soil Conservation in the Palouse Area of the Northwest

Oscar R. Burt

Control theory is applied to the farm level economics of soil conservation in a model which uses depth of topsoil and percentage of organic matter therein as the two state variables. An approximately optimal decision rule was tested against the optimal rule and found to be excellent; errors in the decision rule were less than one percent within the region in state space of practical consideration. Results suggest that intensive wheat production under modern farming practices and heavy fertilization is the most economic cropping system in both the short and long run in the Palouse Area except under low wheat prices.

Key words: control theory, dynamic programming, Palouse area, soil conservation.

In many respects, it appears that the economics of soil conservation has been a neglected subject in agricultural economics during the last two or three decades except as it relates to stream pollution and externalities. The most obvious reason for this apparent lack of interest in the subject is the view that advances in technology have made soil resources per se of less consequence for agricultural production. One outstanding example of the impact which technical change has had is in nitrogen fertilization since World War II.

In 1940, Ibach focused on topsoil in the Corn Belt as the critical resource determining value of agricultural land and used pounds of nitrogen per acre in the topsoil as a measure for estimating land values. With cheap sources of inorganic nitrogen made available by modern technology and its widespread use, this attention to topsoil as a source of nitrogen is largely obsolete. In a sense, topsoil was transformed by modern technology from a primarily stock resource into a largely renewable resource for purposes of practical decisions. But rising energy costs the last few years reemphasize the role of relative costs in delineating the important economic issues during any particular era.

In spite of advances in technology, those already experienced and forthcoming, economic trade-offs in soil conservation can be important. Economic knowledge in soil conservation, which is usually quite specific to localized areas and regions, could be important in national agricultural policy decisions (Benbrook), as well as useful information for improved resource allocation at the farm level. The primary purpose of the research reported here was to explore what could be learned by an application of modern economic methodology (control theory) to a region which is prone to soil erosion. In addition to these illustrative empirical results, it is shown that the approximation method given in Burt and Cummings (1977) works extremely well in applications to soil conservation.

The issue of externalities and social costs of sedimentation and pollution in streams has been avoided purposely in this study. But, insofar as soil losses impose these additional costs on society, there exists an incentive for government to subsidize soil conservation measures and/or to penalize farming systems which are relatively erosive on the soil.

The Wheat-Pea Area of the Palouse

The study area is what is commonly called the wheat-pea area of the Palouse, lying mostly in eastern Washington and western Idaho. The soil is rich, and precipitation is usually adequate to produce relatively high yields of wheat, but the topography is rolling hills with

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steep slopes which create soil erosion problems when farmed. The average slope of the land is about 13%, but some of the steeper farmed slopes approach 50% (Pawson et al.). This region probably has the roughest topography of any area in the United States that is planted to significant acreages of wheat.

The soil is deep loess, with a soil mantle depth of over 100 feet, except in the bottoms of the draws where the minimum depth is about 10 feet. Therefore, soil erosion does not threaten the most basic soil resource, namely, the soil mantle of potentially productive parent material.

The primary hazards from soil erosion are gullying and loss of organic matter and topsoil. Depth of topsoil varies considerably in relation to slope and location on the hill. The tops of the hills have relatively shallow topsoils of less than 6 inches, with a relatively low percentage of organic matter. In general, the depth of topsoil increases with movement down the slopes of the hills, reaching 24 inches near the bottom, the average depth on the lower slopes being 21 to 24 inches. Percentage organic matter in the top 6 inches tends to increase with the depth of topsoil and averaged about 3.3% in 1960 (Pawson et al.).

Specification of the Model

Because soil losses are not a threat to the soil mantle itself on the loess soil of the study area, two state variables, (*a*) depth of topsoil and (*b*) percentage of organic matter in the top 6 inches of soil, would appear to capture the essential information in the dynamic optimization problem of soil conservation decisions. State variables in a dynamic optimization problem must encompass sufficient information on the decision process so that when the variables are at given levels at a point in time, the history of the decision process is almost completely subsumed for purposes of optimal decisions in the future. The state variables can hardly subsume all of the pertinent information on the history of the decision process, but must do so within the limits of approximations which are considered acceptable for an empirical model. The two state variables specified here will suffice if the soil at a given site is relatively homogenous in its vertical profile below the topsoil. Gullying is not a serious problem when farming practices are within the limits implied by the crop rotations allowed in this study.

Strictly speaking, there are many other state variables associated with plant nutrients and the soil chemistry, but these are swept aside and the focus is on variables more directly affected by erosion. Plant nutrients and various measures of the soil chemistry are affected by soil erosion, but physical soil losses and changes in organic matter (our two state variables) should indirectly measure a substantial part of the influence of erosion on individual nutrients and changes in the soil chemistry, as well as some of the changes in the biological base of the soil.

For a given soil (particular location), depth of the topsoil and percentage of organic matter taken jointly probably reflect general soil fertility quite well. This statement should not be construed to mean that these two variables explain most of the variation in fertility across locations because the basic parent material and other factors change across locations. In soil conservation decisions, the concern is with changes in productivity over time at a given site; thus, it is expected that the two state variables jointly reflect changes in fertility with sufficient accuracy if the fertilization, cultural practices, and crop rotations also are taken into account in the dynamic model.

Another important role of these two state variables is to measure indirectly soil structure, which is fundamental to soil aeration and permeability. In the steeply rolling hills of the Palouse, good water penetration of the soil is extremely important in crop production. Poor soil structure on steep slopes could seriously depress wheat yields because of poor utilization of rainfall. Soil structure also has a direct effect on the erosion process itself.

Decision variables encompass all possible farming practices and crop rotations which jointly affect soil organic matter, physical soil losses through erosion, and net cash flow from the land resource. "Lumpy" investments, such as construction of terraces, are not considered here, but the type of analysis undertaken is a prerequisite to economic analysis of such investments. Obviously, some method must be devised to reduce the number of decision variables to a feasible number, preferably one or two.

The empirical measures and data for this application came from Horner et al. and Pawson et al. Those measures and data largely determined the set of cultural practices and rotations to be considered. Fertilization and cultural practices were taken as given for a particular rotation, which relegated decisions

to a choice of rotations. It turned out that a single decision variable, percentage of the land in wheat, could be used by eliminating rotations that were dominated by others with at least as high net returns and less soil loss. Changes in organic matter are highly correlated with soil losses, which made the dominant rotations based on soil losses also dominant with respect to changes in organic matter. One exception was a rotation with high frequency of green manure crops. Net returns for this rotation were relatively low and it would appear to be relevant only under conditions of low organic matter. Rather than introduce a second decision variable, frequency of green manure crops, the simpler model with one decision variable was used.

Although the percentage of land area in wheat cannot be treated as a strictly continuous variable, the model was specified with a continuous decision variable so that an approximation procedure for dynamic optimization models could be evaluated precisely. If one is willing to interpolate between rotations already tested in experiments and small modifications in these rotations, then the measures required in the economic analysis can be estimated for many different levels of the decision variable (percentage of land in wheat). There is also an opportunity to use different rotations on several areas of the total farm and thus provide additional levels of the decision variable. Consequently, treatment of the decision variable as if it were a continuous variable is not a constraining or limiting assumption.

Crop rotations tend to be a rather static concept where a separate field is visualized for each year of the rotation. To be completely accurate, crops grown on various fields of the farm within the past few years would need to be introduced as state variables, and a decision variable would be required for each field to designate which crop to plant. Nevertheless, a model containing only depth of topsoil and percentage of organic matter as state variables, with average percentage of the land in wheat as a decision variable, will work well because the state variables change slowly over time. In fact, the discrete time period of the dynamic model could be specified as a five- or ten-year period without much loss in precision, but an annual model is used. The derived decision rule from the annual model can be interpreted rather loosely because crop rotations may be changed infrequently with essentially no loss in economic efficiency. The appropriate criterion is maximum present value of net returns from the land resource over an infinite planning horizon. If the farmer's planning period is finite, it is assumed that the market for land will reflect the implicit value associated with various levels of the state variables. The following notation is introduced: x is depth of topsoil in inches; y is percentage organic matter in the upper six inches of soil; u, percentage of land in wheat; r, the discount rate (in real terms adjusted for inflation); $\phi(u,x,y)$, annual soil loss function (inches); $h(u,x,y)$, annual organic matter loss function (same units as y); and $G(u,x,y)$, annual net returns function (dollars per acre). The dynamic optimization model can be stated as

$$(1) \qquad \sum_{t=1}^{\infty} G(u_t,x_t,y_t)/(1 + r)^t,$$

a maximum with respect to $u_1, u_2, \ldots$, subject to

$$(2) \qquad x_{t+1} = x_t - \phi(u_t,x_t,y_t),$$

$$(3) \qquad y_{t+1} = y_t - h(u_t,x_t,y_t).$$

Estimation of Functional Relationships

All of the empirical measures and data are taken from Pawson et al. and Horner et al. To some extent, the model had to be simplified to accommodate the limited information available, and the data base is about twenty years old.

In seeking data and/or the necessary functional relationships for an application in soil conservation economics, nothing comparable to the information in Pawson et al. and Horner et al. could be found, let alone in published form. Information on the dynamics of organic matter and its influence on crop yields is particularly scarce. For regions with a shallow soil mantle, one would need to quantify the influence of a declining root zone on crop yields. Because there are deep loess soils in the Palouse, there is no need to measure this influence.

The twenty-year-old data raise two questions: (a) Are relative prices and costs relevant today and in the future? (b) Has technology changed so much that the basic biological and physical relationships are no longer a good approximation? The problem of relative prices and costs is dealt with by considering a range of wheat prices while holding other prices and costs constant. A proportionate increase in all prices and costs will not affect optimal inter-

temporal allocation of soil resources, except for slight distortions in the short run emanating from such factors as fixed costs in machinery. More precisely, a proportionate increase in the net return function $G(\cdot)$ in equation (1) will have a neutral influence, as can be seen by the derived decision rule equation in Burt and Cummings (eq. 26, p. 16).

Because wheat price is treated as a variable parameter, it can be deleted from the discussion on relative costs and prices. Field peas and alfalfa hay are the other crops in the rotations considered. The analysis was done using 1958 costs and prices assumed by Pawson et al., \$3.50 per hundredweight and \$15.00 per ton for peas and alfalfa, respectively. These crop prices are about 25% less than the average prices received by farmers in Washington around 1958. Apparently because of the limited local market for hay and the dominance of the Palouse in the national market for field peas, Pawson et al. discounted these prices somewhat. The result is a bias against soil conservation.

The adjustment factor to transform costs into 1978 dollars is 2.66, based on prices paid by farmers for production items, taxes, interest, and wages. The average prices received by U.S. farmers during 1954–58 were \$4.67 per hundredweight and \$20.82 per ton for peas and alfalfa hay, respectively. Inflation of these prices by the factor 2.66 gives \$12.42 and \$55.38 for peas and hay. Average prices during 1974–78 were calculated for comparison, but the averaging was done in deflated dollars. Then the results were inflated to 1978 dollars because of the rapid rate of inflation during the period; the results were \$12.15 and \$64.24 for peas and alfalfa, respectively. Adjusted prices of peas in the two periods are almost identical, but the price of alfalfa is about 20% higher in the latter period. With respect to prices and costs in 1978 compared to 1958, we conclude that the price of alfalfa hay was enough greater in 1978, that the soil conservation analysis reported below is somewhat biased toward greater wheat production, and thus, more exploitive use of the soil resource. Of course, the critical unknown is long-run trends in relative prices and costs during the decades ahead.

In regard to the second question, dealing with technological changes, it would appear that the changes have been heavily weighted in the direction of larger wheat compared to alfalfa yields. However, greater wheat yields enter symmetrically with wheat price in determining gross returns from wheat, so that parameterization of wheat price can be interpreted as changed yield expectations with fixed price or a change in price with fixed yield.

Technological changes that lower production costs probably have been about equally distributed among the three crops used in the rotations. Cultural practices and levels of fertilization assumed in Pawson et al. were quite advanced for actual farming practices during that time; the level of elemental nitrogen fertilization was as high as 100 pounds per acre in the rotations used to develop empirical relationships for this study.

No attempt was made to project technological change into the future because it is such a multidimensional phenomenon that the effects on intertemporal allocation of soil could be either exploitive or conserving. Consequently, the functional relationships in (1) through (3) are assumed constant over time.

The data presented in table 18 of Pawson et al. (p. 51) on various crop rotations is used as the primary basis for determining the functions $G(u_t,x_t,y_t)$, $\phi(u_t,x_t,y_t)$, and $h(u_t,x_t,y_t)$, i.e., annual net returns, soil losses, and organic matter losses. Annual changes in organic matter for the first ten rotations in their table 18 are given in the last row of table 15 (p. 31); the changes are from a base of 3.3% organic matter. Comparable changes in organic matter from three of the remaining thirteen rotations of table 18 were obtained from a linear regression between organic matter changes and soil losses. The regression used only rotations that included alfalfa hay and winter wheat, because these rotations dominated the other rotations on the basis of net returns per unit of soil losses. Six rotations ultimately were selected as an empirical basis for estimating the three functions in (1), (2), and (3); these were the rotations associated with rows 3, 8, 10, 18, 20, and 23 in Pawson's table 18.

Relatively heavy nitrogen fertilization of wheat is assumed (Pawson et al., table 11, p. 27). Average depth of topsoil is 18 inches and average organic matter is 3.3%.

A relationship between wheat yields and the state variables is required, and this was available in Pawson et al. (p. 66):

$$(4)\qquad Y = a + 35.1\,(1 - .9^{x})(1 - .6^{y}),$$

where x is depth of topsoil and y is percentage of organic matter in the top 6 inches of soil.

The parameter "a" is a constant representing yield theoretically obtainable on subsoil.

Gross returns and costs per acre for each rotation are given in Pawson et al. for average topsoil depth and organic matter equal to 18 inches and 3.3%, respectively. Percentage of land in wheat under each rotation is also available. An important task was to incorporate the influence of state variables, topsoil and organic matter, into the net return structure of each rotation. Multiplication of (4) by the product of wheat price and the proportion of land in wheat provides a term which measures the effect of the state variables on returns, viz.,

$$(5) \qquad 35.1(1 - .9^{x})(1 - .6^{y})P_{w}u/100,$$

where P_w and u are the price of wheat and percentage of the land planted to wheat, respectively. Net returns for a given rotation are adjusted downward by subtracting out (5) with $x = 18$ and $y = 3.3$; then (5) is added back as an algebraic term to get an equation in x and y.

Let the net returns partitioned in this way be denoted

$$(6) \quad R(u;P_w) + uP_w(35.1)(1 - .9^{x})(1 - .6^{y})/100.$$

For each of the six "efficient" rotations selected, as described earlier, there is a unique value of u and a calculated value of $R(u;P_w)$ at a given wheat price. A quadratic function was fitted to these six data points to get an estimate of $R(u;P_w)$ with price at \$1.60 and \$1.20 in 1957–58 dollars (\$4.25 and \$3.20 in 1978 dollars). These two fitted equations serve as the empirical estimate of $G(u,x,y)$ in (1) and are of the general form,

$$(7) \quad b_0 + b_1u + b_2u^2 + cu(1 - .9^{x})(1 - .6^{y}).$$

Parameter values for the two different prices of wheat are given in table 1.

Fertilization rates, particularly nitrogen, are implicit in the function $R(u,P_w)$ given in (6) and increase directly with u, the percentage of land in wheat. Fertilization rates vary across the crop rotations, and consequently, change with the level of u. However, data were not available to permit fertilization rates to be made functions of the state variables, and this is recognized as an important limitation when the state variables are substantially depleted from existing levels, particularly in the one state variable model presented below.

Table 1. Parameters for the Net Return Equation

Wheat Price	b_0	b_1	b_2	c
(\$ 1957–58)				
1.60	5.41	.06635	−.001023	56.16
1.20	5.48	−.02453	−.001089	42.12

Note: These parameters and prices can be converted to a measure in 1978 dollars by multiplication by 2.66.

The two wheat prices of \$4.25 and \$3.20 in 1978 dollars probably bracket the most likely prices to prevail in the near future. During 1970–79, the average wheat price received by farmers in the United States was \$3.62, when calculated in constant dollars and measured in 1978 dollars. Therefore, \$4.25 might be viewed as a relatively high price based on recent experience, but average prices in Washington have frequently been higher than the U.S. average in recent years (40¢ in 1978).

The rotation data in Pawson et al. provide organic matter losses from a base of 3.3%, but this information is not adequate to estimate $h(u,x,y)$ in (3). A linear relationship between average annual changes in organic matter (percent) and the level of organic matter at the time of initial sampling is presented in figure 3 of Horner et al. (p. 10), which suggests that a linear first-order difference equation would describe the dynamics of soil organic matter. The average of annual changes over several years is a good estimate of year-to-year changes for a given level of organic matter because the changes are so small.

The following general relationship is postulated for soil organic matter changes in the top 6 inches of soil:

$$(8) \qquad y_{t+1} - y_t = \alpha(u) + \beta y_t, \ \beta < 0.$$

The constant term $\alpha(u)$ is dependent on the crop rotation; but within the decision model, the percentage of land in wheat, u, determines the crop rotation. The parameter β was estimated to equal -0.01 from the graph in figure 3 of Horner et al. Checks on the data suggested that β was quite stable across many rotations and approximately equal to -0.01.

The intercept $\alpha(u)$ in (8) was estimated for each of the selected six rotations from the information on annual changes in organic matter from a base of 3.3% given in Pawson et al., under the assumption that β equals -0.01. From (8), it is seen that

$$(9) \qquad \alpha(u) = y_{t+1} - (1 + \beta)y_t.$$

The information on individual rotations permits calculation of the right-hand side of (9) when $y_t = 3.3$. The six rotations gave six data points for u and $\alpha(u)$, to which a quadratic function was fitted. Using this equation for $\alpha(u)$ and (8) with $\beta = -0.01$ gave the following estimate:

$$(10) \quad h(u,x,y) = -.0452 + .857(10)^{-4}u + .478(10)^{-6}u^2 + .01y.$$

Notice that depth of topsoil, x, does not enter in (10) and $h(u,x,y)$ is defined as losses in organic matter.

Unfortunately, sufficient data or information from published work could not be found to estimate the influence of soil organic matter on erosion losses. Therefore, soil losses were estimated as a function of the decision variable u, independently of the state variables, which does not allow organic matter to reflect its favorable influence on soil structure and associated reduction in soil losses. Soil losses are given in Pawson et al. for each rotation, which provided six data points in association with the six selected rotations. A quadratic function was fitted on these data points to get

$$(11) \quad \phi(u,x,y) = .0025 + .000261u + .1286(10)^{-5}u^2,$$

which completes the empirical measurement task.

Analysis of the Model

Solution of the optimization problem in (1) to (3) results in a decision rule expressing the decision variable u as a function of the state variables x and y. An approximation to this decision rule was obtained by using the methodology presented in Burt and Cummings (1977). An exact solution can be obtained by application of nonlinear programming to the optimization problem (Burt and Cummings 1970). Probably the most practical method to get an exact solution to a problem of this dimension is with dynamic programming (Bellman).

The approximately optimal decision rule for the soil conservation application is a special case of solving equation (26) in Burt and Cummings (1977, p. 16); only one equation out of the pair given there is required because there is only one decision variable. A simple computer program was written to calculate the solution of the equation implied by the approximately optimal decision rule. Each state variable was started out at its lower bound and systematically incremented after a solution for the decision variable was obtained for a given pair of values of the state variables. This procedure generated the decision rule for the entire domain of the two state variables. Solutions were computed for a range of interest rates, too, but results reported here are for a 6% rate; the decision rule was quite stable for rates of 3% to 8%.

Under a wheat price of $4.25 per bushel in 1978 dollars, the decision rule is at its upper boundary of 85.7% wheat for nearly the entire domain of the state variables. This upper bound is continuous winter wheat with clean cultivation once in seven years. The only exception is at extremely low levels of organic matter, less than 1.5% if topsoil is 6 inches or more. In other words, when the topsoil is 6 inches deep or more and soil organic matter is 1.5% or more, 85.7% of the farm's cropland should be in wheat.

This intensive utilization of the land is not as exploitive as it might seem when the wheat is fertilized quite heavily with nitrogen, as is assumed in this model. Under this land utilization, equilibrium soil organic matter is about 3.5%, and annual soil losses are around 4.75 tons (.035 inches) per year. At this rate of soil loss, it would take twenty-eight or twenty-nine years to lose an inch of topsoil.

When wheat price is reduced to $3.20 per bushel in 1978 dollars, the decision rule is much more interesting, although this is a rather low price for wheat. The decision rule is summarized in figure 1, with contours on the decision rule surface. As would be expected, a small part of the farm is planted to wheat when soil organic matter is low simultaneously with a relatively shallow top soil, and vice versa.

In following the decision rule in figure 1 with 3% organic matter, it would take twenty-eight years to lose an inch of topsoil when its depth is now 18 inches, and it would take thirty-eight years to lose an inch if topsoil depth is only 7 inches. The decision rule puts 85.7% and 69% of the farm in wheat in these two respective states. Consequently, we see that the farm is heavily planted to wheat even with as low a price as $3.20 per bushel.

Following the computed decision rule will ultimately reduce the depth of topsoil to such a shallow layer that normal tillage operations will start mixing the subsoil into the existing topsoil and tend to dilute the organic matter

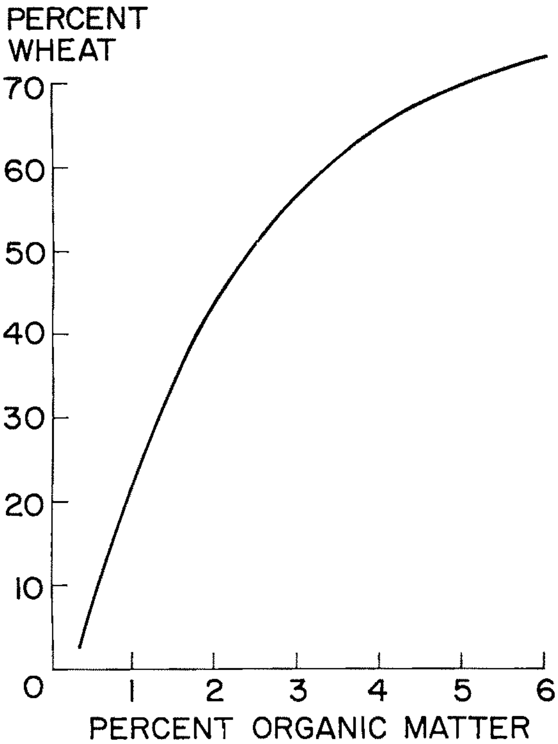

Figure 1. Decision rule with wheat at \$3.20 per bushel (percentage of land in wheat)

content. Average depth of topsoil in the study area was about 18 inches in 1960 (Pawson et al.), so it will take many more years to lose enough soil to create this situation where subsoil is mixed into the topsoil. A rough calculation suggests about 400 years to go from 18 to 6 inches of topsoil when following the decision rule for \$3.20 wheat, and about 330 years when following the rule for \$4.25 wheat. During a time span of this length, additional topsoil might be formed under this relatively intensive cropping system with wheat, but the model makes no allowance for new topsoil to be formed from beneath that already existing.

Nevertheless, a model which assumes a relatively shallow topsoil is of interest for farms and parts of farms where the topsoil is already thin. Many of the upper slopes of the hills have 6 inches or less of topsoil now.

A Single State Variable Model

A modified model is formulated under the assumption that the topsoil has eroded away and left only 6 inches. In addition, we assume that the tillage operations are to a depth of 6 inches, which incorporates new subsoil material into the layer of topsoil as soil is eroded away. Therefore, high soil losses make it more difficult to build up or increase soil organic matter in the top 6 inches.

The above model for two state variables can be reduced to a single state variable model by a simple relationship between $\phi(u,x,y)$ and $h(u,x,y)$. Because the topsoil will be kept at 6 inches depth by mixing subsoil with topsoil that is eroded away, the percentage of organic matter in year $t + 1$ is given by

$$(12) \quad y_{t+1} = y_t[6 - \phi(u_t,x_t,y_t)]/6 - h(u_t,x_t,y_t).$$

The term in square brackets expresses the dilution effect on organic matter of soil erosion losses.

The state variable x for depth of topsoil is set equal to 6 in (12), which gives a simplified difference equation for changes in the percentage of organic matter of the soil, namely,

$$(13) \qquad y_{t+1} = y_t - g(u_t,y_t),$$

with $g(u,y)$ defined as losses in organic matter during the year. The specific empirical relationship for (13) is obtained by substitution of (10) and (11) into (12) and rearranging the results to get the general form of (13). The expression for $g(u,y)$ is

$$(14) \quad g(u,y) = -.0452 + .857(10)^{-4}u + .478(10)^{-6}u^2 + [.01042 + .435(10)^{-4}u + .2143(10)^{-6}u^2]y.$$

The only modification in the annual net return function $G(u,x,y)$ is to set x equal to 6, which reduces the number of arguments to only two.

The approximately optimal decision rule of this model was calculated by the method given in Burt and Cummings (1977) and compared with the exact decision rule calculated by a dynamic programming algorithm. The dynamic programming algorithm was used with extremely precise accuracy to insure that any differences in the decision rules would be detected. The discrete intervals of approximation were 0.01 and 0.0001 for the state and decision variables, respectively; both are measured in units of percent. The dynamic programming algorithm also used linear interpolation for values between the discrete intervals.

The error in the approximately optimal decision rule was less than one-half of one percent of the optimal value of the decision variable (percentage of land in wheat) when the

state variable was in the interval between 1.0% and 6.0% organic matter. These results are for a 6% discount rate and a $3.20 wheat price in 1978 dollars. The error was somewhat larger when the state variable was less than 1.0; for example, the errors were 0.7% and 1.2% of the optimal value when soil organic matter was 0.9 and 0.8, respectively. But this largest percentage error for organic matter at 0.8 was only 0.2% of the land area in wheat in absolute terms, clearly trivial and meaningless in a practical sense.

We conclude that the approximately optimal decision rule is very accurate in this soil conservation application. Comparable results should be obtained in other dynamic optimization problems where the state variables change slowly and smoothly over time; in particular, good results should be typical for economic applications to soil conservation.

The optimal decision rule is given in the first two columns of table 2 and in figure 2. The equilibrium state for organic matter is 2.885% and the optimal percentage of land in wheat at the equilibrium state is 56. Annual soil losses would be 2.9 tons per acre in the equilibrium state, which implies an inch of soil loss about every forty-five years.

Table 2. Single State Variable Decision Rule and Marginal Values of Organic Matter

Organic Matter	Optimum Wheat Area	Marginal Value Organic Matter[a]
(%)	(%)	($ 1978)
0.50	8	45.03
0.75	16	53.14
1.00	23	57.72
1.25	29	59.75
1.50	35	59.93
1.75	40	58.89
2.00	44	56.97
2.25	48	54.52
2.50	51	51.48
2.75	54	48.41
3.00	57	45.19
3.25	59	42.04
3.50	61	38.92
3.75	63	35.91
4.00	65	33.07
4.25	66	30.39
4.50	68	27.85
4.75	69	25.48
5.00	70	23.30
5.25	71	21.24
5.50	72	19.37
5.75	72	17.65
6.00	73	16.12

Note: Wheat price in 1978 dollars was $3.20 and the discount rate was 6% in the analysis.

[a] Marginal discounted value of net returns associated with an increment to organic matter at the beginning of an infinite planning horizon.

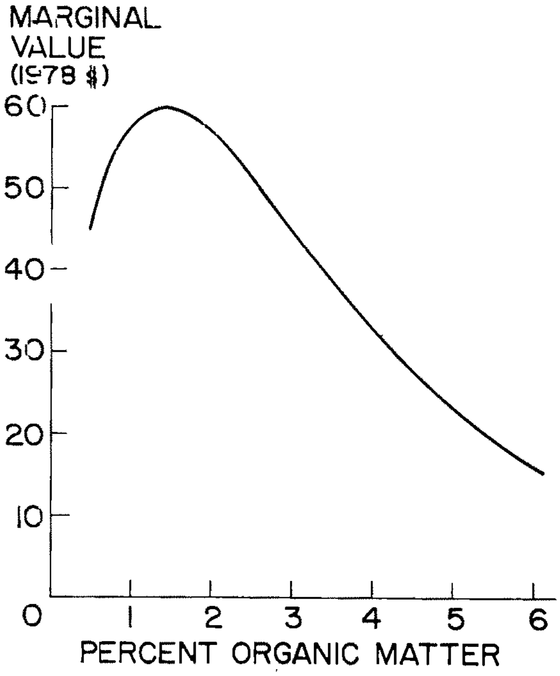

Figure 2. Decision rule with wheat at $3.20 per bushel

Marginal values associated with an increment to organic matter at the beginning of an infinite planning horizon are given in the last column of table 2 and are graphed in figure 3. These values would be the Lagrange multiplier in a Kuhn-Tucker theory framework (Burt and Cummings 1970) or continuous time-control theory model (Hadley and Kemp). In a dynamic programming model, these values are the slope of the functional equation (Burt and Cummings 1977, appendix).

Note how these marginal values first increase at low levels of organic matter, reach a maximum at about 1.5, and then decline monotonically. This is the same structure as the marginal curve to a classic physical productivity curve from the theory of the firm. These quite high marginal values illustrate the value of organic matter in a farming system, even though large amounts of inorganic nitrogen fertilizer are used.

When wheat price is increased to $4.25 per bushel in 1978 dollars, the decision rule hits the upper boundary of 85.7% wheat if organic matter is greater than or equal to 1.5%. Even at 1.0% organic matter, the optimal percentage of the farm to plant to wheat is 75. The equilib-

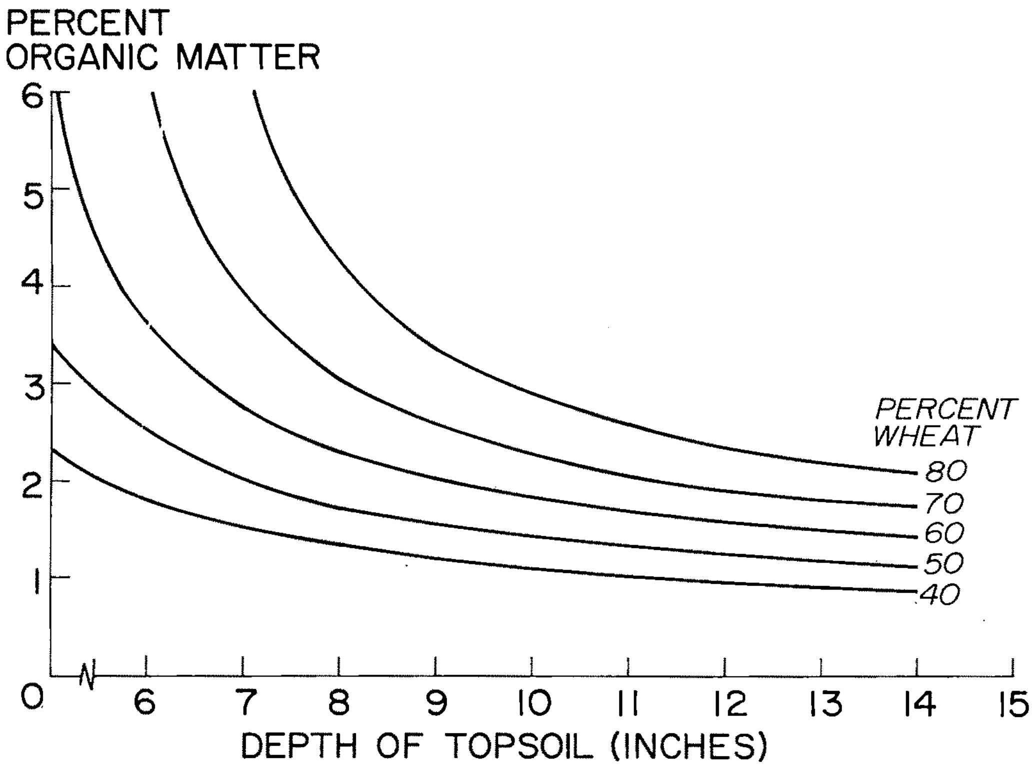

Figure 3. Marginal values of organic matter with wheat at $3.20 per bushel

rium state of organic matter is only 2.15% under the higher price, compared to 2.89% when the wheat price is $3.20. An inch of soil is lost about every twenty-eight years, and it is this relatively heavy soil loss in association with the dilution effect of the subsoil which depresses organic matter.

Concluding Remarks

The methodology of approximately optimal decision rules given in Burt and Cummings (1977) was shown here to be accurate in soil conservation decision models when the state and decision variables are continuous. The approximation methodology is based on a linear approximation to the functional equation of dynamic programming in the "neighborhood" of the equilibrium state. Apparently, this neighborhood in mathematical analysis is sufficiently large in empirical problems of conservation economics that it encompasses nearly the entire domain of the decision rule, only losing its accuracy as the state variables approach zero. This fortunate result stems from the slow changes in the state variables over time under an optimal decision rule in conjunction with discounting of net returns. The methodology is readily extended to stochastic models as well (Burt).

The results of this study demonstrate that relatively high grain prices exacerbate soil erosion problems, a proposition long held by economists writing on the economics of soil conservation (see Bunce and Ciriacy-Wantrup). Nevertheless, empirical results for the Palouse suggest that intensive wheat production with good cultural and fertilization practices is economically justified in the long run, as well as for immediate net returns. The extra losses of topsoil and organic matter, compared to more forage in the cropping system, are within economic limits and not a threat to long-run productivity of the soil. Problems are of a localized nature on the steepest slopes and hilltops, which should have a specialized cropping system applied insofar as it is feasible without creating too many technical inefficiencies on modern, large-scale farms.

Unless there is a substantial increase in the

price of forage relative to grain crops, it would appear that these conclusions would prevail in the foreseeable future. Although the analysis was done with what appears to be too low a relative price for alfalfa hay, technological change has substantially increased wheat yields, which probably more than compensates. The cultural practice of no-till farming combined with modern herbicides gives this conclusion even greater credibility.

These results for the Palouse cannot be extrapolated to other regions, such as the problem areas of southern Iowa and northern Missouri, for several reasons. First, climates are much different and row crops have their own unique hazards. Second, the deep loess soils of the Palouse are uncommon, and a shallow soil mantle is extremely vulnerable to soil losses which could ultimately destroy the water storage capacity of the soil. Third, gulleying from water erosion in some climates and soils is so serious that major investments in terraces are the only long-term solution if grains are to be a large part of the rotation.

Unfortunately, data are not available for comparable analyses in most regions, nor does it appear that the necessary measurements are being taken to produce a homogenous time series of observations. A critical set of data is that required to estimate the difference equations for soil losses and organic matter changes, i.e., (2) and (3), which characterize the dynamics of the problem. Also, considerable agronomic experimentation over an extended time horizon is needed to estimate yield responses to the state and decision variables, the basis of $G(u,x,y)$ in (1).

In view of rising energy costs and world population pressures, a comprehensive research program administered so that there is continuity in the process should be undertaken in the regions where soil erosion is a major threat. A minimum planning horizon for the research projects would be a decade, but reliable data to estimate the dynamics of organic matter changes would probably require annual measurements over a quarter-century. Current research that relates to these empirical measurement problems is almost always sporadic and without any continuity; consequently, the conditions under which the data are collected are not homogenous enough to provide reliable relationships among the variables.

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A New Analytical Framework for the Fertilization Problem

Edgar A. Lanzer and Quirino Paris

A novel control model for technical and economic analysis of fertilizer recommendations is based on Liebig's Law of the Minimum, Mitscherlich's relative yield theory, and the notions of yield plateau and soil fertility carry-over. The empirical model consists of a multistage separable programming specification which maximizes the discounted stream of net revenues subject to crop response and fertility carry-over functions. The model is applied to the wheat-soybean cropping system in Southern Brazil. It is found that, while the optimal fertility target levels are within a small range of those determined by Brazilian agronomists, their maintenance recommendations could be substantially improved.

Key words: Brazil, crop response, fertility carry-over, nutrient nonsubstitution, optimal control, relative yield, yield plateau.

The analysis of yield response to fertilizers has been recently enriched by an original proposal of Cate and Nelson. These soil scientists suggested that for agronomic purposes and for certain crops, it may be convenient to postulate that the relationship between yield and major nutrients is a linear response and plateau (LRP) function. They argued that this simplified specification is nonetheless capable of capturing the essential information of yield response to nutrients such as potassium, phosphorus, and even nitrogen.

This interesting proposal has found little receptivity among agricultural economists who, as Perrin writes, "tend to think of the world as having smooth curves rather than corners" (p. 57). To date, Perrin's study seems to constitute the only economic analysis which utilized the LRP specification and compared it with the traditional polynomial response model. Perrin's conclusions are of great interest: "It will be surprising to some that the LRP provides recommendations as valuable on the average to farmers as those from the quadratic function. . . these particular results should serve to cast some doubt on the widespread (among economists) notion that fertilizer response should always be analyzed by fitting a smooth response surface" (pp. 59–60).

The proposal by Cate and Nelson seems relevant not only because it introduces explicitly the notion of plateau maximum ("a phenomenon that many agricultural economists have noted—that response curves often tend to be quite flat on top" [Perrin, p. 57]); but, more important, because it explicitly reintroduces into the response analysis the agronomic principle known as "the law of the minimum," formulated by von Liebig around 1850. This "law" states that "the yield of any crop is governed by any change in the quantity of the scarcest factor, called the minimum factor, and as the minimum factor is increased the yield will increase in proportion to the supply of that factor until another becomes the minimum. If another factor, not at the minimum, is increased or decreased, the yield would not be affected" (Redman and Allen, p. 454). Therefore, one fundamental implication of Liebig's principle is the absence (or the very limited possibility) of nutrient substitution. With the adoption by agricultural economists of the polynomial response model, the nonsubstitution hypothesis and the yield plateau were completely discarded from economic analyses.

In this paper, we propose a method for estimating response functions of the von Liebig type together with fertility carry-over relations. The LRP model of Cate and Nelson is

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first modified into a piecewise linear and plateau model estimable by linear spline techniques. The relative yield theory of Mitscherlich, widely used by agronomists and soil scientists, is also incorporated into the model. Second, the single-nutrient responses are combined into a minimum function that is a generalization of the Leontief production function. Third, the estimated carry-over and response functions are assembled into an economic control model for optimal fertilizer recommendations, which takes the form of a multistage separable convex programming model. The model is finally applied to experimental Brazilian data featuring an eight-period, wheat-soybeans-cropping system.

The Yield-Nutrient Response Model

Abstracting from error terms, observed yields are known to be a function of many variables such as

$$(1)\qquad y = f(\mathbf{W}, \mathbf{S}, \mathbf{Z} \mid \mathbf{G}, \mathbf{O}),$$

where y stands for yield, **W** is a vector of weather variables; **S** is a vector of soil type variables such as percentage of clay content, pH, soil depth, moisture-holding capacity, redox potential; **Z** is the vector of total supply of macronutrients, that is $\mathbf{Z} = \mathbf{B} + \mathbf{X}$, where **B** is the vector of nutrients' natural supply already in the soil and **X** is the vector of fertilizer applications (the relationship of **B** to soil tests will be examined in the next section); **G** and **O** stand for vectors of genetic load and other factors (such as planting density, for example) which are assumed to condition the yield-nutrient relationship.

Although a simplification of reality, relation (1) is yet too general both for deriving testable hypotheses and for practical implementation of fertilizer recommendations. Many agronomists, for example, have followed Mitscherlich's original suggestion contained in the "principle of relative yields." It was Bray (1954, 1958, 1963), however, who provided a full explanation of the principle as well as of the conditions for its validity. Assuming only one variable nutrient, for the moment, the principle of relative yields postulates that (1) can be respecified as

$$(2)\qquad y = A \cdot g(b + x \mid \mathbf{G}, \mathbf{O}),$$

where A is a parameter representing the maximum attainable yield given some levels of weather and soil variables, **W** and **S**, $g(\cdot)$ is a function called "relative yield response," b represents the nutrient's level already in the soil, and x is the corresponding application. As Mitscherlich postulated it, this function does not depend on weather and soil variables. From the definition of A, the maximum yield attainable given **W** and **S**, the function $g(\cdot)$ varies between zero and one; hence, its name of relative yield function.

According to Bray (1954, 1958, 1963), relation (2) would be valid only for the so-called immobile nutrients, such as phosphorus and potassium. Nevertheless, Hildreth found no significant interaction between soil type, weather, and nitrogen levels when corn yields were expressed in logarithms in a discrete response model fitted to a large set of experimental data. He states (p. 68) that this result "confirmed the a priori belief that equal percentage effects were a more plausible assumption than equal absolute effects." The principle of relative yields may thus have a practical validity even beyond the conditions prescribed by Bray. In any event, the principle is an important tool employed by soil scientists for the design of fertilizer recommendations (see Rouse).

The relative yield theory proposed by Mitscherlich and described by (2) contains an implicit assumption about separability of weather and soil type variables, on one hand, and nutrients on the other. Suppose, in fact, that the general yield-nutrient relationship can be represented adequately by a weakly separable function with respect to the partition (set of weather and soil type variables, set of nutrients), such as

$$(3)\qquad y = h(\mathbf{W}, \mathbf{S})g(b + x \mid \mathbf{G}, \mathbf{O}).$$

It is now evident that Mitscherlich's maximum yield parameter A, when measured in crop experiments, is a function of given levels of weather and soil type variables. Hence, by combining (2) and (3), we conclude that a more explicit formulation of the relative yield model is

$$(4)\qquad y = A_{ws}g(b + x \mid \mathbf{G}, \mathbf{O}),$$

where A_{ws} is now a location parameter measuring the yield plateau of a given experiment. The practical and relevant consequence of the weak separability assumption stated in (4) is to provide a simple and powerful criterion for pooling experimental data of different years and soil classes. This conclusion is supported

by the empirical results discussed later. In this context, therefore, the location index A_{ws} estimates the yield plateau of a given experiment conducted with weather conditions **W** in a soil class **S**. Furthermore, reliable estimates of A_{ws} are not difficult to obtain in view of the general shape of the yield response postulated by some soil scientists and illustrated in figure 1. This figure was reproduced from a widely adopted textbook of soil science (Russell, p. 49). It exhibits a yield response curve with a plateau maximum rather than a point maximum. The interval (k_1, k_2) in figure 1 is considered to be quite wide for macronutrients such as nitrogen, phosphorus, and potassium (Corey and Schulte, p. 31). The notion of a plateau maximum yield, A, is consistently found in the functions proposed by several soil scientists such as Mitscherlich: $y = A[1 - \exp(-c(b + x))]$, Balmukand: $y^{-1} = A^{-1} + c(b + x)^{-1}$, and, more recently, Cate and Nelson: $y = \text{Min}[A, c(b + x)]$.

The formalization of the yield-nutrient relationship involving two or more nutrients follows von Liebig's "law of the minimum," according to which macronutrients cannot substitute for each other (or the substitution region is very limited). Barber is quite explicit in this regard: "economists . . . have pointed out that when crops are fertilized to a certain yield level, there are a number of different combinations that will give the same yield . . . but since P cannot substitute for K in the plant, any substitution must be small in amount" (p. 210). Tisdale and Nelson, too, assert that "the substitution concept is not a sound long-time

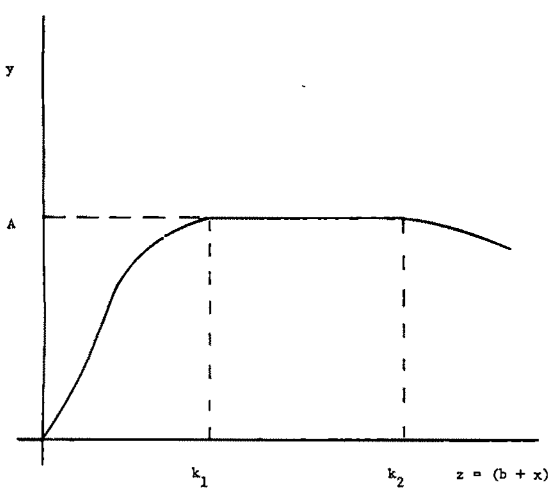

Figure 1. Yield response (y) to total supply of variable nutrient (z)

approach" (p. 618). Hence, combining the proposals of several agronomists (see also Waggoner and Norvell), we postulate the following multinutrient response function:

$$y = A_{ws} \min_{i \in I} [g_i(b_i + x_i)], \tag{5}$$

where I is the set of macronutrients—nitrogen (N), phosphorus (P), potassium (K)—and the other symbols are as before. The conditioning factors **G** and **O** are omitted for convenience. The relative yield functions $g_i(\cdot)$ are, in general, nonlinear and therefore, model (5) is an extension of the well-known Leontief production function with fixed input-output coefficients.

Fertility Carry-Over

The specification of the fertilization model must be completed with the discussion of the fertility carry-over problem. This is because "as fertilizer is applied in increasing quantities, it becomes apparent that increased attention must be given to the value of carry-over. In many cases the cost of fertilization is charged to the crop treated. However, carry-over fertilizer is like money in the bank and is part of fertilizer economics. Hence, it is apparent that if we are to make a critical evaluation of fertilizer use, the carry-over value must be considered" (Tisdale and Nelson, p. 538). Although agricultural economists have written only a few papers on this subject (Kennedy et al.; Stauber, Burt, Linse; Fuller), the above quotation clearly indicates the importance that agronomists attribute to fertility carry-over. In fact, fertilizer recommendations made by soil scientists seek to build and to maintain the level of soil fertility at the minimum level required to achieve the yield plateau (Rouse, p. 16–17). But how is soil fertility to be measured?—by means of soil tests. Agronomists consider a clear understanding of soil test measurements to be of fundamental importance for the design of fertilizer recommendations. This is because, in many instances, most of the available information concerning a particular farming site comes embodied into a single soil sample. It is from the chemical analysis of such a small piece of information that fertilizer recommendations are to be made. In the terminology of optimal control theory, soil test measurements are "sensor measurement signals" of a dynamic stochastic process (Athans). Soil-testing

chemical methods, on the other hand, constitute the sensors themselves. Ideally, the soil sensors should produce measurements expressed in the same units employed to measure fertilizer quantities, irrespective of everything else. However, such an idealized set of sensors has not yet been produced by soil scientists.

Therefore, the quantity b of a given nutrient available in the soil is to be measured by soil tests, b^*, which soil scientists assume to be proportional to the true values of b. In other words, $b = \lambda b^*$, where λ is a proportionality factor. The condition required for the validity of the above assumption is that the chemical form of the nutrient in the soil be constant (Bray 1954, 1958, 1963). However, such chemical forms vary somewhat with soil type. The pragmatic approach followed by soil scientists, then, is to classify soils into homogenous groups according to their λ values and, since the λ's are specific of each nutrient, a classification of soils in terms of λ for potassium may be different from a classification of the same soils made on the basis of λ for phosphorus. Soil scientists suggest that estimates of λ for a given nutrient i can be obtained from the following simple formula:

$$\lambda_i = x_i/(b^*_{it} - b^*_{io}), \tag{6}$$

where b^*_{io} is a soil test measurement for the ith nutrient prior to a fertilizer application of x_i units of the same element, and b^*_{it} is a soil test measurement made before the next crop. Since one of the explicit goals of fertilization is that of building up the fertility levels in the soil, b^*_{it} is greater than b^*_{io} and, therefore, $\lambda_i > 0$. In conclusion, since the λ coefficients are known to vary with soil type, model (5) incorporating soil test measurements becomes

$$y = A_{ws} \operatorname*{Min}_{i\epsilon I} [g_i(\lambda_{is}b^*_i + x_i)]. \tag{7}$$

The above discussion, while concentrating on the interpretation of soil test measurements, also makes clear the necessity for casting the problem of making fertilizer recommendations into a dynamic framework. From the point of view of the soil laboratory that makes such recommendations, the control problem of achieving and maintaining the fertility stock at any desired level requires updated estimates of the level of extractable nutrients in the soil. Those estimates do not necessarily require the knowledge of past fertilizer applications, yields, and weather conditions (although these may help in some cases). Instead, updated estimates of the level of extractable nutrients in the soil are to be obtained from the chemical analysis of soil samples. Thus, the dynamic extension of the yield-nutrient response model incorporates fertility carry-over equations, which are specified in terms of (a) the state variables that can be observed, i.e., soil test measurements, and (b) the decision variables that may affect the level of the state variables, i.e., fertilizer applications. The equations of motion describing the transfer of fertility in the soil from period to period are, therefore, specified as

$$b^*_{it} = h_i(b^*_{it-1} + \lambda_{is}^{-1} x_{it-1}), i\epsilon I, \tag{8}$$

where b^*_{it} is the soil test result for the ith nutrient at the beginning of period t, and x_{it-1} is the quantity of the ith nutrient applied as fertilizer in period $t - 1$. Notice that while the term $(\lambda_{is}b^*_i + x_i)$ in (7) represents the total supply of the ith nutrient as measured in fertilizer units (e.g., pounds of P_2O_5 per acre), the term $(b^*_i + \lambda_{is}^{-1}x_i)$ in (8) represents the total supply of the ith nutrient as measured in soil test units (e.g., ppm of P). Equations (7) and (8) constitute the model of yield-nutrient response which can be called the dynamic relative-yield-nonsubstitution model. To estimate the yield response function (7), one needs to know the parameters λ_{is}, which, in turn, are obtained from the estimation of the fertility carry-over equations (8).

Economic Analysis of Fertilizer Recommendations

The principal objective of the approach proposed in this study is to evaluate the appropriateness of the fertilizer recommendations provided to farmers by extension agents. Typically, such recommendations are obtained from tables constructed by soil scientists who classify the soils of a given region and determine the "appropriate" fertilizer's build-up and maintenance doses. In general, these tables do not reflect possible variations of the economic environment.

In order to verify the adequacy of these tables, we postulate that farmer's objective is to maximize the discounted stream of net revenues subject to the yield response and fertility carry-over model (7) and (8) described in previous sections. Symbolically, and for a

planning horizon of T periods, such a model can be represented as

$$(9)\quad \text{Max } \pi = \sum_{t\epsilon T} (1 + r)^{-t} \left(P_y \cdot A \cdot g_t - \sum_{i\epsilon I} P_i x_{it}\right)$$

$$\text{subject to } g_t - g_i(\lambda_{is} b^*_{it} + x_{it}) \leq 0.$$

$$b^*_{it} - h_i(b^*_{it-1} + \lambda_{is}^{-1} x_{it-1}) = 0,$$

$$b^*_{i1} = \text{given, } x_{it} \geq 0,\ i\epsilon I,\ t\epsilon T,$$

where P_y is the output price, P_i is fertilizer prices, r is the interest rate, and other symbols are as before. The b^*_{i1} initial conditions represent known soil test levels at the beginning of the planning horizon T. For simplicity, inputs other than fertilizers are not included in (9), but it would not be difficult to adapt the model for their inclusion. Also notice that, once the maximum yield parameter A is known (through experimental data or agronomists' suggestions), function (7) can be rewritten as a relative yield function $g_t = y/A = \min [g_i(\lambda_{is} b^*_{it} + x_{it})]$ or, equivalently and more operationally, as max g_t subject to $g_t - g_i(\lambda_{is} b^*_{it} + x_{it}) \leq 0$, i = N,P,K and $t\epsilon T$. This last reformulation is used in model (9).

The exogenous information of model (9) is represented by output and input prices, the discount rate, the crop's maximum yield A, the estimates of the relative yield response and fertility carry-over functions, and the initial levels of soil fertility. The endogenous information obtained by solving model (9) is constituted by the optimal fertility targets, b^*_{it}, $i\epsilon I$, $t\epsilon T$, $t \neq 1$, and the optimal fertilizer applications, x_{it}. The fertilization strategy so derived is obviously dependent upon the initial soil test levels. Furthermore, farmers periodically acquire new information on fertility levels by means of soil tests. They can, and probably do, use this information for updating their fertilization strategy. A conceptual modification of the problem is then required to accommodate this situation. The incorporation of the updating information into the programming formulation can be achieved by the "moving horizon" concept. Under this concept, "every decision made is a first-period decision with a (finite) horizon" (Theil, p. 155). The control rules obtained from model (9) can be summarized as follows: for a given expected yield plateau and a given set of expected prices, there will be an optimum stock of soil fertility to be maintained by means of periodic supply of fertilizer inputs. The stock of soil fertility present at any given point in time is measured via soil tests. The optimum quantity of fertilizer (control) to apply in any given period will be the difference between the current soil fertility level and its desired stock level (target). In this framework, knowledge of the carry-over functions are all that is necessary to exert control over the system once soil test targets are provided by the solution of (9).

Lastly, notice that if the carry-over functions in (9) are concave, then the set of feasible solutions remain convex and a separable programming version of (9) can be solved directly with conventional linear programming techniques.

Application to Wheat-Soybeans in Southern Brazil

The discussion in previous sections was centered around the design of a model representing yield-fertilizer relationships incorporating agronomic principles and procedures. This section reports the results of an application of that model to evaluate the economics of fertilizer recommendations currently made for the wheat-soybeans double-croping system in Southern Brazil. The data available for the empirical research gathered from thirty-eight different experiments precluded the joint estimation of all yield responses and carry-over functions. Linear carry-over functions were estimated for phosphorus and for potassium under the assumption of a geometrically declining process and of an autoregressive error term. The estimation of carry-over functions generated estimates of λ coefficients, which, in turn, were used to compute total availability of nutrients from the knowledge of soil test levels and fertilizer application for each observation. Constrained linear spline regression techniques were used to estimate the wheat and the soybean responses to total phosphorus and to total potassium. Splines equations were constrained to attain a maximum of 1, or 100%, at, or before, a certain level of supply of the variable nutrient; this level was considered sufficiently high to attain the yield plateau according to the experience and suggestion of Brazilian agronomists. Data from different sites and years were pooled under the principle of relative yields. To do so, a proportion of the maximum observed yield at each experiment was used as a proxy for the expected

yield plateau of that experiment. Such proportion was estimated within the regression framework.

Wheat response to nitrogen was estimated directly under the specification of a Mitscherlich type function (organic matter content being used as a proxy for the level of soil nitrogen; carry-over nitrogen is considered to be insignificant in the context of wheat-soybeans in Southern Brazil). A nonlinear Gauss-Newton procedure was used to estimate all carry-over and yield response functions. This procedure allowed for (*a*) the direct estimation of the parameters of carry-over equations including the autoregression coefficient and (*b*) constraining the parameters of the spline in order to ensure quasi-concavity. In Southern Brazil, wheat and soybeans are grown in succession year after year with each crop occupying the land for roughly six months. Thus, the unit of time used in the analysis is half a year.

The results were as follows.

Carry-Over Functions

The econometric specification adopted for the carry-over functions of phosphorus and potassium was the following Koyck distributed lag specification.

$$(10)\quad b^*_{it} = \Theta_i(b^*_{it-1} + \lambda_i^{-1}x_{it-1}) + u_{it},$$

where b^*_{it} $(i = P,K)$ is the soil test level of the ith nutrient at the beginning of period t, Θ_i is a rate of geometric decline and $u_{it} = \rho_i u_{it-1} + e_{it}$, where e_{it} is a white-noise Gaussian error term. Lagging (10) one period, multiplying by ρ_i, and substracting from (10), one arrives at

$$(11)\quad b^*_{it} = \rho_i b^*_{it-1} + \Theta_i(b^*_{it-1} - \rho_i b^*_{it-2}) + \Theta_i\lambda_i^{-1}(x_{it-1} - \rho_i x_{it-2}) + e_{it}.$$

The parameters of (11) were directly estimated with a nonlinear regression procedure. The results are shown in table 1. For the case of phosphorus, a slight modification of (11) was adopted because data from two different soil types were pooled for the following reason. Local soil scientists believe that the λ^{-1} coefficient for P in one soil type (clay soils) is half the value as for other soil types. Hence, this information was entered in (11) with the help of a dummy variable for soil type. Two observations are in order with respect to the results shown in table 1. First, the estimates of the geometric decline coefficients for both P and K are relatively close to the unity. This means that fertilizer carry-over is highly significant for both nutrients in soils of Southern Brazil. Second, from the estimates of the λ_i^{-1} $(i = P,K)$, one concludes that, upon taking the inverse of such coefficients, (*a*) each ppm unit of P in a soil test for a clay soil is equivalent to an application of 48.26 kilograms of P_2O_5 per hectare on clay soils (this value reduces to 24.13 for other soils), and (*b*) each ppm unit of K on a soil test for all soils is equivalent to an application of 3.73 kilograms of K_2O per hectare. In the case of phosphorus, an unconstrained model was also fitted to the data. The estimates in this case were $\lambda_p = 51.69$ for clay soils and 22.80 for other soils.

Table 1. Carry-Over Estimates for Phosphorus and Potassium in Southern Brazil

Parameter Symbol[a]	Estimates for Phosphorus	Estimates for Potassium
θ_i	0.88950	0.81390
	(0.02090)[b]	(0.01210)
λ_i^{-1}	0.02072[c]	0.26820
	(0.00230)	(0.03653)
ρ_i	−0.67470	−0.41540
	(0.04163)	(0.04876)
Number of Observations	345	420
R^2	0.7881	0.3542

[a] According to equations (10) and (11).
[b] Asymptotic standard errors in parentheses.
[c] For clay soils; for other soils multiply the estimate by two.

Yield Response Functions

Once the estimates of the λ coefficients were available from the estimation of the carry-over functions, the total supply of phosphorus and potassium (z_P and z_K) were computed for each observation according to $z_i = \hat{\lambda}_{is}b^*_i + x_i$, $(i = P,K)$. Data used for the estimation of a yield response to any nutrient included only the observations for which the experience of local soil scientists indicated that the level of other nutrients was nonlimiting (i.e., within the range k_1, k_2 in fig. 1). To represent algebraically the yield response function we chose a linear spline specification for the following two reasons. First, it is a natural extension of the linear response and plateau model of Cate and Nelson, and explored by Perrin. Second, it allows greater flexibility of functional form

and does not impose any substitution requirement as, for example, the polynomial specification. The linear spline specification used in all cases (except for wheat response to nitrogen) was as follows:

$$(12) \quad y_{ne} = \alpha M_e \sum_{m=1}^{m=6} \beta_m V_{mne} + u_{ne},$$

where y_{pe} is yield (kg./ha.) observed on the nth plot of the eth experiment, M_e is the maximum observed yield of the eth experiment (notice that αM_e is used as proxy for the expected yield plateau of the eth experiment A_e) and where $V_{1ne} = z_{ne}$, $V_{2pe} = \text{Max}(L_1 - z_{ne}: 0)$, $V_{3ne} = \text{Max}(L_2 - z_{ne}: 0)$, etc., according to the requirements of the linear spline specification. The fixed knots L_m were chosen as middle points of classes of soil test levels currently adopted in fertilizer recommendation tables in Southern Brazil (the last knot, L_5, was located beyond the level that soil scientists consider sufficient to attain the yield plateau). The relative yield function represented by the spline formulation was postulated to attain its maximum of unity (100%) for some range of z starting at L_m $(m < 5)$ and extending to L_5 at least. Under this constraint, the spline should satisfy:

$$(13) \quad \beta_1 L_1 + (\beta_1 + \beta_2)(L_2 - L_1) + (\beta_1 + \beta_2 + \beta_3)(L_3 - L_2) + \ldots + (\beta_1 + \beta_2 + \ldots + \beta_5)(L_5 - L_4) = 1,$$

or, upon simple algebraic manipulations of (13):

$$(14) \quad \beta_1 = L_5^{-1} - (L_5 - L_1)L_5^{-1}\beta_2 + (L_5 - L_2)L_5^{-1}\beta_3 - \ldots - (L_5 - L_4)L_5^{-1}\beta_5.$$

Equation (14) represents a linear constraint upon the parameters of the linear spline formulation of the yield response. By substituting (14) into (12) and rearranging terms one arrives at

$$(15) \quad y_{ne} = \alpha R_{1ne} + \alpha\beta_2 R_{2ne} + \ldots + \alpha\beta_5 R_{5ne} + \alpha\beta_6 R_{6ne} + u_{ne},$$

where $R_{1ne} = M_e L_5^{-1}$, $R_{2ne} = M_e[V_{2ne} - (L_5 - L_1)L_5^{-1}V_{1ne}]$, $R_{3ne} = M_e[V_{3ne} - (L_5 - L_2)L_5^{-1}V_{1ne}]$, etc. The parameters of (15) were estimated by a Gauss-Newton algorithm, which further allowed constraining the β_m $(m > 2)$ estimates to be nonpositive (a requirement to ensure concavity of the estimated spline except for an initial range where increasing returns could occur). Parameter β_1 was recovered with the help of equation (14). The statistical results of the estimations of the responses of wheat and of soybeans to total supply of phosphorus and of potassium are summarized in table 2. The information of this table allowed for the computation of the estimates of knots in the spline formulation of the

Table 2. Linear Spline Regression Results for Soybeans and Wheat Responses to Phosphorus and Potassium

	Estimates of Soybeans Responses to		Estimates of Wheat Responses to	
Parameter Symbol[a]	Phosphorus	Potassium	Phosphorus	Potassium
α	0.906100	0.912400	0.883700	0.882300
	(0.013332)[b]	(0.010010)	(0.017720)	(0.019160)
β_1	0.007324[c]	0.013350[c]	0.002630[c]	−0.02074[c]
	(—)	(—)	(—)	(—)
β_2	−0.005194	−0.010680	0.001368	0.040480
	(0.000604)	(0.003481)	(0.001091)	(0.037550)
β_3	−0.001706	−0.000080	−0.003316	−0.015310
	(0.000299)	(0.000003)	(0.000653)	(0.015250)
β_4	0.000000	−0.001860	−0.000380	−0.003310
	(—)	(0.000975)	(0.000413)	(0.003080)
β_5	−0.000397	−0.000530	0.000000	−0.000920
	(0.000248)	(0.000394)	(—)	(0.001480)
β_6	−0.000060	−0.000280	−0.000313	−0.000320
	(0.000180)	(0.000198)	(0.000146)	(0.000370)
Number of Observations	340	273	179	425
R^2	0.7885	0.8819	0.9009	0.9485

[a] According to equation (12).
[b] Asymptotic Standard Errors in parentheses.
[c] Computed according to equation (14).

relative yield responses. These estimates are presented in table 3.

For two reasons, the estimation of wheat response to nitrogen did not follow the same methods employed for phosphorus and potassium. First, the soil test for nitrogen is not a direct measurement of nutrient as in the case of P and K. Instead, nitrogen supply of the soil is indirectly evaluated through the organic matter percentage content of the soil. Second, nitrogen carry-over is not important within the context of wheat-soybeans in Southern Brazil: soybeans produce their own nitrogen via Rhizobium bacteria and rainfall leaches fertilizer nitrogen very rapidly in that region. Therefore, it was decided to estimate the relation between soil nitrogen, applied nitrogen and yields directly via the yield response function. The model adopted in this case was a Mitscherlich type function:

(16)

$$y_{ne} = \alpha M_e[1 - \exp(c^* b^*_{Nne} + c\, x_{Nne})] + u_{ne},$$

where y_{ne} is observed yield of the nth plot of the eth experiment, M_e is the maximum observed yield at the eth experiment, b^*_{Nne} is the soil test level for percentage organic matter of observation n, e, and x_{Nne} is fertilizer nitrogen applied on the nth plot of the eth experiment (in kg. of N per ha.). Notice that, in (16) the term within brackets is relative yield response to total nitrogen. This, in turn, is defined as $z_N = \lambda_N b^*_N + x_N$, where, in view of (16), $\lambda_n = c^*/c$. Table 4 reports the statistical results obtained with model (16).

From the estimates of c^* and of c, one gets

Table 3. Knots of Estimated Relative Yield Response Functions: (L_m; g_m) for m = 0, 1, 2, . . . , 5

Phosphorus			Potassium		
L_m[a]	g_m for Soybeans[b]	g_m for Wheat[b]	L_m[c]	g_m for Soybeans	g_m for Wheat[b]
0	0.000	0.000	0	0.000	0.000
75	0.549	0.197	40	0.534	−0.830[e]
225	0.868	0.799	110	0.721	0.553
375	—[d]	0.905	185	0.915	0.885
525	0.997	—[d]	260	0.970	0.970
675	1.000	1.000	410	1.000	1.000

[a] In kg. of P_2O_5 per ha.
[b] As percentage of the expected yield plateau.
[c] In kg. of K_2O per ha.
[d] No change of slope at this level.
[e] Dull estimate due to lack of observations in the range 0 to 40 kg. of K_2O per ha.

Table 4. Regression Results for the Wheat Response to Nitrogen

Parameter Symbol[a]	Point Estimate	Asymptotic Standard Error
α	0.8507	0.01328
c^*	−0.5634	0.05571
c	−0.0429	0.02990

Note: There were 158 observations; R^2 = 0.8823.
[a] According to equation (16) in the test.

λ_N = 13.13, i.e., each percentage unit of organic matter is estimated to be equivalent to an application of 13.13 kilograms of N per hectare. In the multiperiod LP model, the continuous function estimated for N was approximated as a convex combination of the following levels of total nitrogen supply: 0, 30, 60, 90, and 120 kilograms of N per hectare.

At this point, all the physical components of problem (9) had been estimated, except for the expected yield plateaus for wheat and for soybeans. According to agronomists of the National Wheat Research Center (CNPT), the expected yield plateaus for wheat and for soybeans at the farm level in Southern Brazil are 1800 kilograms per hectare and 2800 kilograms per hectare, respectively. The prices used in the programming model were (Cr$/kg) 5.61 for N, 7.06 for P_2O_5, 2.49 for K_2O, 2.03 for wheat, and 1.84 for soybeans. They are average prices during 1976 for Southern Brazil. An interest rate of 3% per semester has been used to discount future cash flows. A planning horizon of four years (eight cropping periods: wheat, soybeans, wheat, etc.) was assumed for the purpose of the economic analysis.

The results of the analysis with the programming model were as follows:

(*a*) optimum soil fertility targets for wheat:
z_N = 57.15 kg. of N/ha. (or 4.35% organic matter content),
z_P = 375.0 kg. of P_2O_5/ha. (or 7.8 ppm of P for clay soils; 15.6 for other soils),
z_K = 202.6 kg. of K_2O/ha. (or 54.3 ppm of K);

(*b*) optimum soil fertility targets for soybeans:
z_P = 456.0 kg. of P_2O_5/ha. (or 9.4 ppm of P for clay soils; 18.8 for other soils),
z_K = 260.0 kg. of K_2O/ha. (or 69.7 ppm of K).

Input prices were also parameterized within the interval of 0.6 to 1.4 times the average prices used in the analysis. The conclusion was that the results found under average

prices were stable, particularly with respect to increases in input prices.

In view of these results, the analysis turned to a critical evaluation of fertilizer recommendations currently made by the agronomists for the wheat-soybeans double-cropping system. Such recommendations do not make a distinction between soil fertility targets for wheat and for soybeans. In either case soil scientists recommend that a level of 9 ppm of P (for clay soils; twice as much for other soils) and a level of 60 ppm of K be maintained in the soil (see UFRGS). Thus, only minor differences between the current recommendations and the computed optimum are detected as far as target levels for soil fertility are concerned (the differences are all in the range of 5% to 15%). Thus, in the analysis that follows, target levels for P and K currently suggested by Brazilian soil scientists will be regarded as optimal recommendations.

In order to maintain the levels of soil fertility at their desired targets, the Southern Brazilian agronomists recommend fertilizer applications of 75 kilograms of P_2O_5 per hectare per cropping period and 40 kilograms of K_2O per hectare per cropping period. Such recommendations can be evaluated through the carry-over equations [see equation (10) and table 3]. Taking the case of phosphorus first, letting $b^*_{Pt-1} = b^*_{Pt} = \beta^*_P$ (where β^*_P is thus defined as the desired target level for P in ppm units of P) and solving for $x_{Pt-1} = \chi_P$ (where χ_P is thus defined as the maintenance application of P in terms of P_2O_5 per hectare per cropping period), one finds that the estimated fertilizer application required to maintain the level of soil phosphorus at any desired level β^*_P is given by $\chi_P = 5.996\ \beta^*_P$ for clay soils and $\chi_P = 2.998\ \beta^*_P$ for other soils. Similarly, for the case of potassium, by letting $b^*_{Kt-1} = b^*_{Kt} = \beta^*_K$ (where β^*_K is thus defined as the desired target for K in ppm units) and solving for $x_{Kt-1} = \chi_K$ (where χ_K is thus defined as the maintenance application of K in kg. of K_2O per ha. per cropping period), one finds that the fertilizer application required to maintain the level of soil K at its desired soil test level is given by $\chi_K = 0.853\ \beta^*_K$. Soil test targets currently adopted by Southern Brazilian agronomists are $\beta^*_P = 9$ ppm of P (for clay soils; twice as much for other soils) and $\beta^*_K = 60$ ppm of K (for all soils). By substituting these values into the equations for χ_P and χ_K just derived, one finds that the maintenance applications levels for P and K should be approximately 54 kilograms of P_2O_5 per hectare per cropping period and 51.2 kilograms of K_2O per hectare per cropping period. These levels contrast with the maintenance levels currently adopted in Southern Brazil: 75 kilograms of P_2O_5 per hectare per cropping period and 40 kilograms of K_2O per hectare per cropping period. In short, even though the target levels are close to the computed optima (relative differences here were found to be in the range of 5% to 15%), it is clear that major modifications of maintenance fertilizer recommendations are in order (the relative differences found here are in the range of 30% to 50%).

The analysis above was centered in the cases of P and K. For nitrogen it has been found that current recommendations should be diminished from 10% to 50%, the difference increasing with increases in the level of organic matter content of the soil. Table 5 gives an overview of costs of alternative fertilization strategies, i.e., current recommendations versus recommendations derived in this research.

Table 5. Yearly Fertilization Costs Required to Maintain Soil Fertility at Desired Targets for Wheat-Soybeans Double-Cropping System (Southern Brazil, 1976 Prices)

	Current Recommendation		Suggested Recommendation	
Item	Quantity[a]	Cost[b]	Quantity[a]	Cost[b]
Maintenance N for wheat[c]	30.0	168.30	20.0	112.20
Maintenance P for wheat	75.0	529.50	55.0	388.30
Maintenance K for wheat	40.0	99.60	50.0	124.50
Maintenance P for soybeans	75.0	529.50	55.0	388.30
Maintenance K for soybeans	40.0	99.60	50.0	124.50
Total cost		1,426.50		1,137.80

[a] in kg. of N/ha. kg. of P_2O_5/ha. and kg. of P_2O_5/ha. for N, D, K, respectively.
[b] in Cr.$/ha.
[c] assuming a 3% organic matter content.

Notice that since both alternatives assume the same fertility targets, no significant change in output is likely to occur. Thus, the gains from the adoption of the recommendations derived in this study would come from a reduction in fertilizer costs. This reduction was estimated at Cr$ 288 per hectare per year, or US$27.30 per hectare per year (July 1976 exchange rate). The relative decrease in yearly fertilization costs would be around 20%, a significant amount.

Conclusions

This paper contains the suggestion of a model for examining fertilizer recommendations that incorporates soil science principles in a rather explicit manner. The use of this model in a practical setting helped to identify significant economic inefficiencies in the case studied. The model depends on several hypotheses adopted in soil science theory. Some of these hypotheses (such as the linear response and plateau) have been examined recently by Perrin with results not inferior to more conventional polynomial specifications.

Although further research effort is certainly warranted on all aspects of the fertilization problem, it seems possible to conclude that the dynamic relative-yield-nonsubstitution model presented here has performed satisfactorily in the wheat-soybeans environment of Southern Brazil. It has indicated that, as hypothesized, fertility carry-over is indeed significant for phosphorus and potassium. As to the dispute among agricultural economists about whether or not the traditional analysis of the fertilizer problem (based upon a polynomial specification of the response function and little concern for carry-over) is adequate, it seems appropriate to quote T. D. Wallace, who wrote: "statistical procedures substitute rather poorly for rigorous modeling based on the foundations of the field of application" (p. 443). The traditional polynomial form of the response function, so far preferred by agricultural economists, was suggested mainly because of its "good" fit. But, as was shown by Perrin and in this study, similar or better fits can be obtained with other functional forms which have the additional advantage of explicitly incorporating agronomic principles. This last point is important for two reasons. First of all, it follows T. D. Wallace's recommendation. Second, it allows a direct dialogue with many agronomists and soil scientists who conduct their fertilizer research on the basis of nutrient nonsubstitution, yield plateau principle, relative yield theory, and the notion of fertility carry-over.

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An Economic Analysis of Expenditures on Agricultural Experiment Station Research

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Experiment station research expenditures are responsive to economic and institutional forces. A four-equation model of resources allocation to state agricultural experiment station research, consisting of demand and supply equations for research, an equation allocating state governmental revenues to station research, and an expenditure identity, is presented. A reduced-form expenditure equation, derived from this model, is fitted to cross-sectional data for forty-eight U.S. states, pooled together for 1960, 1965, and 1970. A large share of the variance in per capita expenditures of state agricultural experiment stations is explained by the variables included in the model.

Key words: experiment station research, indigenous applied research, reduced-form expenditure equation, resource allocation.

The last decade can be characterized by a growing skepticism of the agricultural research establishment. Some have argued that agricultural researchers have been captured by the interests of large farmers or by large, private, farm-input supply firms (e.g., Hightower). Others have argued that the agricultural research establishment has been unresponsive to human resource, environmental, and income distributional issues (e.g., Mayer and Mayer). Some of these concerns have been expressed in recent changes made in the type of federal support for agricultural research.

The primary sources of funds available to state agricultural experiment stations have been federal funds appropriated on a formula basis and funds appropriated for agricultural research by state governments. Although formula funds are granted to the states on a matching basis, nonfederal support of research, which is largely state appropriations, has been at a level that substantially exceeds the federal matching rate in all states. In recent years, state appropriations for research have averaged about 60% of the total funds for state agricultural experiment station research (U.S. Department of Agriculture 1969). The U.S. Congress recently has established a federally funded competitive research grant program for agricultural research open to all scientists, those at both public and private institutions. Also, the Administration attempted in 1977–78 to substitute competitive grant funds for formula funds. These changes have caused a reassessment by the directors of the state agricultural experiment stations of their funding base.

Only a few studies have attempted an analysis of expenditures on agricultural experiment station research. Schultz (1971) first explicitly recognized the potential economic significance of disparities in funding state experiment stations. Hayami and Ruttan have argued for an economic analysis of public institutions involved in economic growth and development. Peterson attempted to identify through regression analysis a few factors that influence the allocation of funds to agricultural research. In his simple model, state nonfarm income emerges as the most important variable explaining total funds available to experiment stations. (See also Schultz, 1956; Heady; Peterson and Hayami.) In the first attempt to model the determination of agricultural research expenditures, Guttman applies a theory of public interest groups. The interest group

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purchases policies that are favorable to its members, in this case agricultural research, in exchange for support (votes and funds) for candidates for public office favoring policies sought by the group. In applying the model to cross-sectional expenditures on poultry, grain, and dairy research in 1969, research expenditures are explained by a limited set of variables hypothesized to affect the demand for research. The analysis, however, ignores the supply of research, an important determinant of the real quantity of research.

We present a four-equation model of resource allocation for state-produced research at agricultural experiment stations, consisting of demand and supply equations for research, an equation for allocating governmental revenues to station research, and an expenditure identity or equilibrium equation. The reduced-form expenditure equation derived from this model includes a traditional set of economic variables determining the demand for research and the supply of research and a few interest-group variables. Our model is tested with cross-sectional data on the forty-eight states of the United States, pooled together for the years of 1960, 1965, and 1970, for total expenditures by state agricultural experiment stations.

The outline of the paper is as follows: the first section specifies a theoretical model of resource allocation to state experiment station research; second section, the data base, the empirical specification of the model, and the regression results are presented and discussed; the last section presents the summary and conclusions.

A Model of Resource Allocation to State Experiment Stations

We propose a model of resource allocation for state-produced research at agricultural experiment stations consisting of demand and supply equations for applied research, an equation for allocating state revenues to station research, and an expenditure identity. We assume that demanders and suppliers of research in a state interact through the state legislature to determine the "equilibrium" size of expenditures on experiment station research.

The research of experiment stations is heavily production-oriented. Cline's data show that about 74% of agricultural experiment station research is production-oriented.[1] Much of agricultural research produces increments to basic knowledge or intermediate products (e.g., discoveries of new biological, chemical, physical, economic, or sociological relationships and advances in the methodology of experimental design and hypothesis testing) that enlarge the set of possibilities available to applied researchers (Binswanger and Ruttan, p. 23) but that may not directly increase production efficiency. However, without advances in basic knowledge, the applied research potential would be rapidly exhausted.

Applied research produces final research products. Some research maintains previous biological advances against adverse environmental conditions that might depreciate gains in crop yields and animal productivity (Griliches 1958; Evenson 1978), and other research (e.g., new or improved inputs, decision-making aids and schemes, and final agricultural products) attempts to increase output.

Demand

Applied agricultural research is an input in the production of agricultural output (Griliches 1964; Evenson 1968, 1971; Peterson and Hayami). We hypothesize a state aggregate demand function for indigenous applied agricultural research. At the state level, farmers, as producers, and land owners seem likely to be the primary beneficiaries. The price elasticity of demand for a state's agricultural products is much larger generally than for a nation's output. If a state produces a small fraction of total national or world output, indigenous agricultural research lowers its farmers' cost curves, increases its share of national output, and only slightly lowers the national (or world) price.[2] Thus, profit-maximizing

[1] The other 26% is allocated to a wide variety of research projects, e.g., home economics, consumer problems, rural and community development, environmental quality. We do not deny that these are important research areas, but we do choose to explain total research expenditures by concentrating on agriculture.

[2] Consider two geographic regions supplying $Q_i^s = S_i(P,\delta_i)$, $i = 1, 2$, where P and δ_i are the price received by suppliers of Q and a supply function shift parameter, respectively. The market demand function for Q is $Q^d = D(P)$, and market equilibrium requires $Q^s = Q^d$. However, the demand function facing region 1 is $Q^d{}_1 = D(P) - S_2(P,\delta_2)$, and the price elasticity of demand for region 1 is

$$\eta_{Q_1P} = (Q/Q_1)\,\eta_{QP} - (Q_2/Q_1)\,\epsilon_{Q_2P},\ \eta_{QP} \leq 0,\ \epsilon_{Q_iP} \geq 0,$$

where η_{QP} is the market price elasticity of demand for Q, ϵ_{Q_iP} is the price elasticity of supply of region i.

Also, the effect of a shift of the supply curve of region 1 due to advances in technology in that region on the market price of Q can be summarized as

farmers of a state should demand indigenous applied research that enhances their efficiency of production and improves their comparative advantage relative to farmers in other states or regions. The benefits from this research accrue largely as producers' surplus to indigenous farmers and as rents to the owners of inputs that are very inelastic in supply (Ayer and Schuh; Evenson 1979), e.g., land and water, other things equal. Farm input supply firms, processors of farm products, and local consumers also may benefit from agricultural research.

Although research products are a public good, indigenous demanders cannot expect to borrow all their research products from other states. Research output, a form of information, has the characteristic of a public good; use by one economic agent does not reduce the quantity available to others. The benefits to users vary, however, and some individuals may be made worse off as more individuals use research output. Potential users cannot be excluded easily; and, for social efficiency, such information should be made available to all potential users at the marginal cost of distribution (Arrow). Basic or intermediate agricultural research produced by one experiment station has the potential for being used (borrowed) by many states, but the potential for widespread direct interstate borrowing of final (applied) agricultural research products is usually more limited because their performance is frequently sensitive to local environmental factors and resource endowments. For example, studies by Griliches (1957) of hybrid corn and by Evenson (1978) of agricultural productivity show the incomplete nature of research-spillover across state and regional boundaries. Thus, a good substitute does not exist in agricultural production for indigenously produced applied research products that are location-specific or that are adapted more perfectly to the needs of indigenous clients than to others. Under these conditions, a state demand function for indigenously produced applied research exists.

The quantity demanded of indigenously applied agricultural research is hypothesized to be a function of the size and other characteristics of a state's agricultural output, agricultural input prices, farmers' education, extension, agricultural research in other states, and the price of indigenous applied research. The characteristics of a state's agricultural output are primary determinants of shifts in the demand for indigenous applied agricultural research. This emphasis on output follows from the positive contribution of agricultural research as an input in aggregate production function studies (Griliches 1964; Evenson 1968, 1971, 1978; Cline) and implicitly to farm profits. Also, the expected increase in farm profits from research oriented to insuring previous productivity gains against adverse and unpredictable environmental conditions is positively related to the size of output. The total value of preventing a 5% loss in output increases with the size of output. Furthermore, Evenson (1968) estimates that 30%–50% of agricultural research expenditures on crop and livestock and poultry research in 1967 were directed to maintenance research.

The diversity of indigenous agricultural products and the size distribution of farms may affect the demand for research. For a state, the intracommodity (within commodity) applicability of research (or economies of information usage) will usually be much higher than intercommodity (between commodity) applicability. Final research products (e.g., inbred corn lines, feedlot management systems, tillage machines, and fertilizer recommendations) are usually commodity specific. The expected returns from agricultural research are such that the marginal effect of a dollar of product output on the demand for research output diminishes as output increases. Thus, the number of agricultural commodities produced indigenously is expected to increase the aggregate demand for indigenous applied research.

The profitability of adopting new technology is a function of the reduction in cost per unit of output and the size of output. Because large farms have more units of output over which to apply cost savings than small farms, the operators of large farms have a greater demand for indigenous applied research because of potential profitability. Thus, holding the size and diversity of agricultural output constant, a larger share of large farms is expected to shift rightward the demand for indigenous applied research. (Feasible new technology might also have a large-farm bias.)

The tenure status of farmers also may affect

$$\frac{\delta_1}{P}\,\frac{\partial P}{\partial \delta_1} = \frac{(Q_1/Q)\epsilon_{Q_1\delta_1}}{\eta_{QP} - (Q_1/Q)\,\epsilon_{Q_1P} - (Q_2/Q)\,\epsilon_{Q_2P}},$$

where $\epsilon_{Q_1\delta_1}$ is the elasticity of supply of Q_1 with respect to δ_1.

At the national or international level, consumers are the primary beneficiaries of agricultural research. The price elasticity of demand for agricultural products at this level is low so the long-term impact of agricultural research is to lower the price of agricultural products and to benefit consumers.

the demand for research. Because benefits of indigenous research accrue as producers' surplus to farm operators and as rents to agricultural inputs that are most inelastic in supply (e.g., land), owner-operators of farms have a greater financial incentive to reveal their demand for indigenous research than do renters and seem likely to be more effective than the combination of absentee landowners and renter-operators (Evenson 1979). Thus, increasing the proportion of owner-operators is expected to increase (shift) the demand for applied indigenous research.

A shift in the relative prices of agricultural inputs can be expected to affect the demand for research. An increase in input prices reduces farmers' profits (and perhaps landowner rents) and can be expected to induce them to search for technical alternatives. These alternatives can be expected to save on the input(s) whose price(s) has increased and to increase the use of inputs that have become relatively cheaper (Hayami and Ruttan, Binswanger and Ruttan). This increase in input price shifts rightward the demand for indigenous applied research.

Farmers' education, extension, and research centers enhance the dissemination of information on agricultural technology. Education enhances the allocative ability of farmers (Huffman; Welch 1970). Extension decodes and repackages research findings so that the technical information can be better understood by farmers and can be applied at the farm level. Outlying research centers of the experiment station also aid the information-disseminating activity. Thus, higher schooling levels of farmers, larger extension activities, and a greater number of research centers speed the adoption of superior final research products, increase farmers' profits and landowners' rents, and increase the (share of) benefits from indigenous research to indigenous producers and owners of indigenous resources. Thus, an increase of farmers' education, agricultural extension, and research centers is expected to shift rightward the demand for research.

For a given state, Evenson (1979) has hypothesized that research output of other states may have two opposite effects on indigenous research demand. Most new research final products are not directly applicable to environmental and resource conditions in other states, e.g., a superior corn variety. Competing farmers in other states are placed at a competitive disadvantage unless new research products are developed for them. Thus, nonborrowable research output in competing states can be expected to shift rightward the demand for indigenous applied research. On the other hand, directly borrowable final research products (e.g., controls for livestock diseases, livestock feed additives, and farm management schemes) from other states obtained from input supply firms, veterinarians, extension personnel, and farm magazines will substitute for indigenous applied research and will reduce the indigenous demand for research.

We hypothesize that the quantity demanded of indigenous applied research is responsive to its price, the shadow price, given that it is not traded in the market at a price. The reason is that demanders face an opportunity cost for public-sector resources allocated to indigenous applied agricultural research. They must forego other public-sector goods and services (e.g., extension, education, welfare, roads) to obtain more indigenous research, or they must incur larger state tax payments, which means foregoing the private goods they otherwise could obtain. Thus, we hypothesize that the quantity demanded of indigenous applied research is negatively related to its shadow price.

Supply

In our model, indigenous applied agricultural research is produced and supplied by agricultural experiment stations. The final and intermediate products of experiment station research consist of technical publications (books, journals, and station bulletins), nontechnical publications, blueprints, new crop varieties or lines, new feed rations and additives, new environmental controls, new decision-making schemes, and training of researchers. The production of research requires, as inputs, the services of administrators, researchers (or scientists), research assistants, and secretaries, as well as scientific publications, office space and equipment, laboratory space and equipment, electronic computers, greenhouse space, experimental plots and farms, and research animals and plants. Salaries and personnel benefits, however, account for about 70% of total obligations (USDA 1966 and 1970).

As a first approximation, we assume agricultural experiment stations produce research outputs at minimum cost. These stations are

nonprofit institutions operating within public land-grant universities that have similar missions and goals, but that place different relative weights on the products from teaching, research, and service. Directors of experiment stations are the managers of these research-producing institutions. They differ in the amount and composition of their entrepreneurial activity, and we assume that they behave as if they are attempting to minimize the cost of producing research final products. This objective implies that directors do not change cost-minimizing input combinations because particular inputs (e.g., new buildings, prestigious research staff) yield satisfaction directly to them.[3]

The supply or cost function of indigenous applied agricultural research is hypothesized to be a function of prices of variable inputs (e.g., wage rates of research assistants and secretaries, rental rates on computers), of the quantity of research output, and of factors exogenous to current resource allocation decisions. The latter set of variables affects the efficiency of research production and, hence, the cost of research. They are the entrepreneurial activity of the station director, the characteristics of the station's researchers, the type of research appointments, and the existence of Ph.D. programs, extension contact with researchers, availability of borrowable research, number of final research areas, and the number of research centers.

Basic and applied research are creative activities; ideas must be combined so that something "new" is produced. This activity seems to require a sustained effort, with periods of intense mental preparation followed by reflection and, hopefully, enlightenment and then by writing and rethinking (Ladd). This implies that a significant share of a researcher's time and mental effort must be allocated to research. Thus, the productivity of research time seems likely to be low if individuals are continually being disrupted (by nonresearch activities) or if their working hours are primarily allocated to nonresearch activities (e.g., teaching, administrative-type activities), because this leaves less time for research. However, researchers may not have enough good ideas (and other resources) to keep their productivity high when all of their time is allocated to research. Thus, the effect of available time for research on the supply of research is a priori uncertain.

Researchers need sources of new ideas and knowledge to enhance the efficiency of producing research. Communication with extension personnel and colleagues is one source. When extension personnel interact with farmers, they learn of new problems facing farmers. Some problems may be solved by drawing upon existing knowledge, but others need to be redefined and relayed to researchers for further analysis. Thus, researchers interacting with extension personnel serve as a potential source of information transmittal on researchable problems.

Although the potential size of the stock of available knowledge is positively related to the number and quality of researchers at an institution, information exchange must occur before efficiency gains can be realized. Interdisciplinary research efforts facilitate communications across disciplines, but the organizational feature that seems most likely to foster exchange of information within and between departments of a university is a strong graduate Ph.D. program (Evenson 1971). Graduate courses taken by research assistants in the basic disciplines (e.g., statistics, chemistry, genetics, botany, economics) are an important source of knowledge and research techniques to be applied to station research projects. Graduate students in general may challenge the ideas of teachers and researchers and provide new ideas. Thus, strong graduate programs both within and outside of agriculture and forestry are expected to increase the efficiency of station research and to shift rightward the supply curve of research.

Borrowable research from other states is another source of new ideas and knowledge. Since the production of original research is expensive relative to distribution of results, borrowing research from other states reduces the costs of indigenous applied research. Not all available research, however, is useful. Basic research and intermediate research products generally have broad applicability because of their fundamental nature. Final or applied research products tend to be commodity- and geoclimatic-region-specific, so they may not be directly applicable in other states. To the extent that borrowing of final research products occurs, it seems likely to be confined

[3] Ruttan (1978) argues that in the United States the combination of centralized (USDA) and decentralized (state) systems of agricultural research results in an organizational structure that behaves similar to firms in a competitive market. Other researchers (e.g., Ault, Rutman, Stevenson) have assumed cost minimization for models of resource allocation in universities.

largely to states located in similar commodity geoclimatic regions (Evenson 1978). Thus, a larger quantity of available outside basic research is expected to shift rightward the supply of indigenous applied research.

The number of different research final-product areas, given the size of a station and the mix of research between crops and livestock, may affect the efficiency of research production. For a small station, supplying research products for a large number of commodities may mean spreading resources thinly, allocating most resources to final products and few to intermediate research products. Low production efficiency may occur because the station cannot take advantage of economies of size in producing research. Thus, increasing the diversity of a state's agriculture, and hence of applied agricultural research, is hypothesized to shift leftward the supply of research, other things equal.

Research centers (experiment stations and substations) are important laboratories for crop, livestock, and agricultural engineering research. The size and location of these centers are important organizational features of research (Evenson 1971, Binswanger and Ruttan). When environmental factors and commodities differ widely among regions within a state, decentralized research centers facilitate adapting technology to local conditions and displaying the results at field days. Centralization of research, however, permits taking advantage of economies of size in the use of expensive laboratory equipment, libraries, and administrative services. Centralization is also necessary for work requiring collaboration across disciplines by highly skilled researchers. Thus, the net effect of research centers on the supply of applied agricultural research is a priori unknown.

Revenue Allocation

In our model, demanders of station research do not pay suppliers of station research directly, but rather decisions are made at the state government level on the share of state revenue to be spent on indigenous applied agricultural research. We add a behavioral equation for allocating state government revenue (McMahon) to agricultural research.

We take the size of total state governmental revenues (includes intergovernmental transfers) as predetermined, but the share of these revenues allocated to agricultural research is endogenous. We hypothesize that political-economic clout is required to obtain funds for agricultural research (i.e., to affect the expenditure share) rather than letting available funds be allocated to the production of other state-provided goods, e.g., education, welfare, roads, parks. The director of the agricultural experiment station and interest groups, representing the interests of demanders of research, play key roles in obtaining these funds. The director initiates requests for research funds from the state legislature based upon his first-hand information of the research cost and (presumably) of the demand for research.[4] This latter information comes from his contact with producer groups, advisory boards, and input supply firms, from direct requests research, and from client feedback through extension personnel. Also, the size (or share) of state revenues allocated to agricultural research is affected by the director's activities (direct or indirect) to obtain legislative support for funding.

Demanders may lobby the state legislator directly or through interest groups to achieve their political influence. Interest groups exchange their votes in state governmental elections for favorable votes by legislators on legislation they support. Although consumer groups and environmentalists might lobby for certain kinds of agricultural experiment station research, we hypothesize that farm owner-operators, operators of large farms, and farm organizations are the strongest lobbyists for agricultural research. Because research benefits accrue largely as producers' surplus to farm operators and as rents to landowners, owner-operators of farms are expected to be stronger lobbyists than renter-operators. Also, because profitability of adopting new technology is a function of the change in cost per unit of output and the size of output, operators of large farms, having more units of output, are expected to be stronger lobbyists for agricultural research than operators of smaller farms.

General and commodity-specific farm organizations can be expected to use their political influence to get funds appropriated for research. The members of commodity-specific farm organizations seem likely to be more

[4] The budgeting process through which the director of the experiment station registers funding requests with the state legislature—directly, or indirectly through a university president and perhaps some governing board—may be an important factor for obtaining support for agricultural research.

homogenous in their research interests than general farm organizations, permitting them to be more decisive and influential in getting funds appropriated for research. The influence of these organizations, however, may be difficult to assess because of overlapping membership, uneven geographical coverage, and withholding of membership data.

The final equation of the model is an expenditure identity or equilibrium equation. A summary of the basic four-equation model we have developed of resource allocation to indigenous applied agricultural research is presented in table 1. The four endogenous variables are entrepreneurial activity of the station director, price and quantity of indigenous applied research, and expenditures on indigenous applied research. To obtain a reduced-form expenditure equation, we assumed that each of the four equations has a $\log_e$ linear form (see appendix). Because of the complexity of the expressions in terms of structural parameters, the coefficients of the reduced-form expenditure equation are difficult to sign.

The Empirical Analysis

The data base, the empirical specification of the variables, and the regression results from fitting the reduced form of the state expenditure equation for experiment station research are presented and discussed in this section.

The Data Base and the Variables

The basic data source on expenditures and other characteristics of the agricultural exper-

Table 1. A Summary of the Model for Resource Allocation to Indigenous Applied Agricultural Research

		Equations			
Variable list		Demand	Supply	Allocation	Identity
(a)	Quantity indigenous applied research[a]	χ	χ		χ
(b)	Size of agricultural output	χ			
(c)	Size distribution of farms	χ		χ	
(d)	Tenure status of farmers	χ		χ	
(e)	Agricultural input prices	χ			
(f)	Farmers' education	χ			
(g)	Commodity diversity of agricultural output	χ	χ		
(h)	Agricultural extension	χ	χ		
(i)	Number of research centers	χ	χ		
(j)	Outside applied research stock	χ			
(k)	Price of indigenous applied research	χ	χ		χ
(l)	Price of indigenous research inputs		χ		
(m)	Entrepreneurial activity of station director		χ	χ	
(n)	Type of station faculty appointments		χ		
(o)	Graduate Ph.D. program		χ		
(p)	Outside basic research stock		χ		
(q)	Size of state government revenues			χ	
(r)	Farm organization membership			χ	
(s)	Expenditure for indigenous applied agricultural research			χ	χ

[a] A "χ" indicates that a variable appears in the designated equation.

iment stations is the USDA publication, *Funds for Research at State Agricultural Experiment Stations and Other State Institutions.* States in the conterminous United States are the unit of observation, and expenditures for the fiscal years of 1960, 1965, and 1970 are used as the dependent variable. Cross-sections are combined to provide a more rigorous test of the model and are chosen at the above five-year intervals to take advantage of the characteristics of agriculture reported in the *Census of Agriculture.*

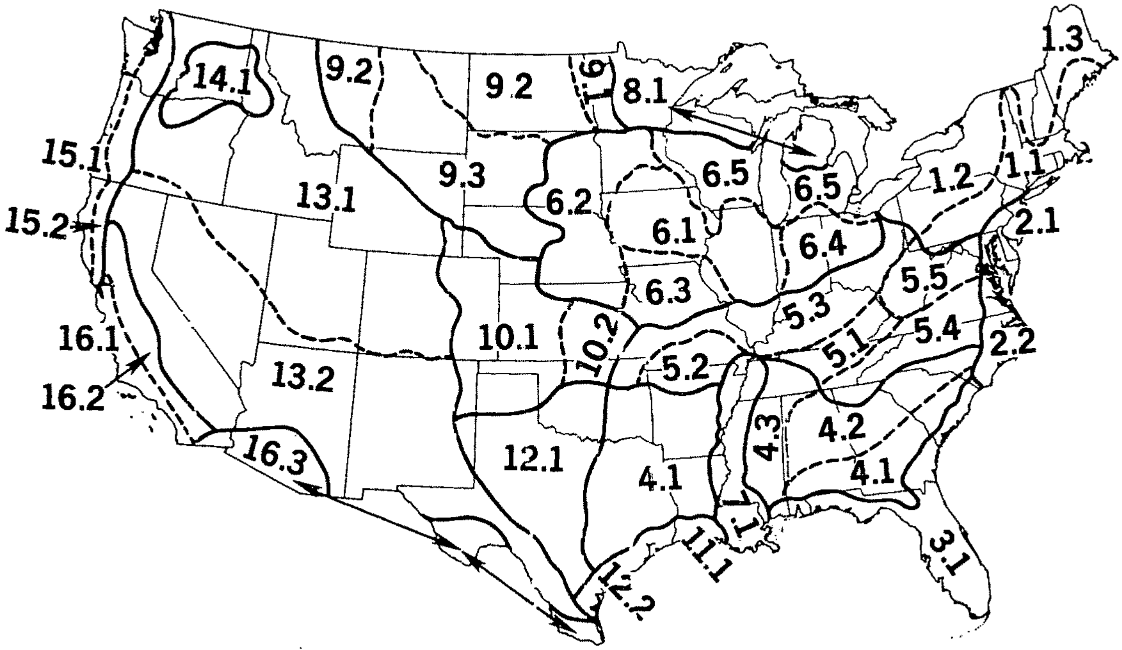
Most of the variables are constructed on a state per capita basis by dividing them by the size of the state's population (U.S. Dep. of Commerce 1961, 1966, and 1971). We are treating public-sector agricultural research as a public good, but per capita expenditures have a more homoskedastic error term than total expenditures. Guttman uses per capita units in his empirical analysis. Finally, dividing both sides of the equation by the size of the population does not prevent one from using the fitted model to explain total expenditures on agricultural experiment station research.

The dependent variable is a state's grand total obligation of funds for the fiscal year by the experiment station (and other state institutions) less nonfederal funds available from fees, sales, and miscellaneous sources then divided by the size of its population. The fees and sales category is excluded because it is dominated by sales of livestock and crop products from research projects.[5] Agricultural output is measured as net annual sales per capita (total value of farm products sold less purchases of livestock and poultry and of noncommercial feeds for livestock and poultry), (U.S. Dep. of Commerce 1963, 1967, and 1973) lagged one year. An index of concentration (diversity) of a state's agricultural output is constructed as the summation of the squared production share of each of eighteen different agricultural commodities or commodity groups. The index is largest if a state's agricultural output consists of only one commodity or commodity group (it is one), and is smallest if a state produces an equal value of each of eighteen different commodity groups (18/324). For input prices, we use only a state's annual average hourly wage rate for hired labor, without board and room (USDA 1961, 1965, and 1970) lagged one year. The main source of interstate variation in other farm input prices is transport costs, except for land. Land rental data for comparable agricultural land do not exist, and land price differences reflect quality differences and a number of economic forces not related to its current rental value for agricultural production. The education level of farm operators is a Welch-weighted (Welch 1966, 1970) average number of years of schooling completed by farm operators (U.S. Dep. of Commerce 1962, 1968, and 1972). Extension is the grand total of a state's expenditures on extension per capita, lagged one year (USDA).

We constructed two measures of research activity outside a given state from data made available to us by Robert Evenson (and described in Evenson 1978). The relevant set of states to consider in constructing these variables was determined by the boundaries of geoclimatic regions and subregions derived from the 1957 *Yearbook of Agriculture* (see figure 1). These areas have relatively homogeneity of soils and climatic factors. The subregional applied-research stock (competitive research) is the summation of past commodity-specific livestock and crop research expenditures, and applied agricultural engineering and farm management research expenditures aggregated over states with similar agricultural subregions outside the state. Applied research expenditures were assumed to have a thirty-year useful life, and linear weights were applied to aggregate over time with seven years of increasing, eight years of constant, and fifteen years of declining weights.[6] Basic research (noncommodity specific research) is applicable over a wider geoclimatic area. The regional basic research stock (borrowable research) is the summation of past basic research expenditures for states in similar geoclimatic regions outside the state. Basic research was assumed to have a forty-year useful life, and linear weights were applied to aggregate over time with seven years of increasing, eight years of constant, and twenty-five years of declining weights. Outside applied and basic research are in per capita units.

[5] The presence of measurement errors in the dependent variable, say due to its inclusive nature, will not generally affect the statistical properties of the estimated coefficients of the model. These errors, however, would affect the qualify of forecasts from the model.

[6] The time shape for the weights is based upon the results of a partial correlation scanning analysis across varying time shapes by Evenson (1978). The pattern chosen gave high correlation of the research variable with agricultural productivity. The same time shape is imposed on all states.



Legend:
1. Northeast Dairy Region
2. Middle Atlantic Coastal Plain
3. Florida and Coastal Flatwoods
4. Southern Uplands
5. East-Central Uplands
6. Midland Feed Region
7. Mississippi Delta
8. Northern Lake States
9. Northern Great Plains
10. Winter Wheat and Grazing Region
11. Coastal Prairies
12. Southern Plains
13. Grazing-Irrigated Region
14. Pacific Northwest Wheat Region
15. North Pacific Valleys
16. Dry Western Mild-Winter Region

Note: One dot equals 25,000 acres of cropland, 1964.

Figure 1. U.S. agricultural geo-climate regions and subregions.

Four characteristics associated with agricultural experiment stations follow. A research center's variable is derived as the number of research stations and substations (USDA, *Professional Workers in State Agricultural Experiment Stations*), including main campus, per 10,000 farms. The average share of budgeted time for research is derived as the number of full-time equivalent station researchers divided by the total number of station researchers engaged full- or part-time in research (USDA, *Funds for Research*). Two variables measuring the size of the Ph.D. degree programs are derived. The station Ph.D.-to-research faculty ratio is the (three-year centered) average number of Ph.D. degrees earned in agriculture and forestry from departments associated with the agricultural experiment station (U.S. Dep. HEW, *Earned Degrees Conferred*) divided by the number of full-time equivalent station researchers. The Ph.D. degrees in other areas is the annual average (two years) number of Ph.D. degrees earned in other areas (excluding agriculture and forestry) at universities associated with agricultural experiment stations (U.S. Dep. HEW, *Earned Degrees Conferred*) relative to the size of the state's population.

The state budget constraint is total revenue per capita of the state government from all sources, including intergovernmental transfers (U.S. Dep. Comm., *Statistical Abstracts*).[7] Income generated in the state, types of taxes, and willingness of the state's people to be taxed are important determinants of the size of this budget constraint. Farm size distribution is measured as the share of large farms (sales ≥ $40,000) and the share of medium-sized farms (sales $2,500–$39,999). The proportion of owner-operators is a weighted-average number of full owners and of part owners. Full

[7] For federal matching funds, each state much at least match the federal fund; with nonfederal funds, including state appropriations, to qualify for the federal support of research. In all states, nonfederal funds for experiment station research are considerably larger than the minimum required to be eligible for federal grant funds. Thus, at the margin, additional federal matching funds have an income but not a price effect.

owners are given an arbitrary weight of 1 and part owners a weight of 0.5. The only accessible farm organization membership data are for cooperatives. The cooperative membership variable is the total estimated number of memberships in marketing, farm supply, and related service cooperatives (USDA, *Statistics of Farmer Cooperatives*) per capita. Because a farmer can be a member of more than one cooperative, there is considerable double counting, but this will be a desirable characteristic when a cooperative's influence is derived from "speaking for its members."

Table 2 presents a summary of the empirical variables, including the symbols associated with each variable, and the sample means and standard deviations of the variables. The table shows that the mean value of expenditures on state experiment station research over the 144 observations is \$1.40 per person and the standard deviation is \$0.93 per person. (No variable measuring the prices of indigenous research inputs is included in the empirical model. There are two main reasons for this inclusion. First, wage and salary data for researchers and research assistants by university are difficult to obtain. Second, observed cross-sectional variation in these prices may be meaningless. Part of the variation would be due to quality differences in the services these individuals perform, to previous experience, and to nonwage characteristics of their job, e.g., learning opportunities, pleasantness of surroundings, city size.)

The Results

The results from fitting a reduced-form expenditure equation by the method of least squares to the 144 pooled observations are reported in table 3. The equation is fitted with interaction terms between ln (*AGOUT*) and *CONC* and between *LARGE* and ln (*ARES*) and with two time-period dummy variables. The impressive characteristic of the results is the generally good performance of the explanatory variables and of the regression model as a whole. The results imply that the demand for agricultural research is price inelastic and that the supply

Table 2. Summary Statistics for Expenditures on U.S. State Agricultural Experiment Station Research, 1960–1965–1970

Variables	Symbol	Unit	Mean	St. dev.
Expenditures on experiment station research per capita	*R*	\$0.1 per person	14.0	9.3
Net agricultural output per capita	*AGOUT*	\$s of output per 1,000 people	2,359.0	2,174.3
Index of commodity concentration of agricultural output	*CONC*		0.21	0.08
Proportion large farms	*LAR*		0.07	0.06
Proportion medium-sized farms	*MED*		0.53	0.15
Proportion owner-operator	*OWN*		0.73	0.09
Wage rate of hired farm labor	*WAGE*	\$ per hour	1.20	0.31
Index of farmers' education	*ED*		1.49	0.28
Extension expenditures per capita	*EXT*	\$ per person	1.39	0.81
Research centers per farm	*CEN*	Centers per 10,000 farms	3.06	4.06
Subregional applied research stock per capita	*ARES*		16.12	19.80
Regional basic research stock per capita	*BRES*		3.92	5.47
Budgeted share of research time	*SR*		0.70	0.12
Ph.D. degrees earned in agriculture and forestry per full-time equivalent researcher	*APHD*	Ph.D. degrees per researcher	0.07	0.08
Ph.D. degrees earned outside agriculture and forestry per capita	*OPHD*	Ph.D. degrees per 1,000 people	0.03	0.03
State revenue per capita	*REV*	\$1,000 per capita	0.984	1.02
Coop membership per capita	*COOP*	Member/1,000 people	2.29	1.85

Table 3. Least-Squares Estimate of Reduced-Form Equation for Expenditures on U.S. State Agricultural Experiment Station Research, 1960–1965–1970 (144 observations)

Variables	Algebraic Form	Estimated Coefficient	t-ratio
Net agricultural output per capita	ln (*AGOUT*)	0.307	3.56
Index of commodity concentration of agricultural output	*CONC*	4.455	2.16
Proportion large farms	*LAR*	2.077	2.28
Proportion medium-sized farms	*MED*	0.464	1.09
Proportion owner-operators	*OWN*	0.756	2.29
Wage rate of hired farm labor	ln (*WAGE*)	0.550	2.10
Index of farmers' education	ln (*ED*)	−0.447	−1.93
Extension expenditures per capita	ln (*EXT*)	0.473	6.53
Research centers per farm	ln (*CEN*)	0.214	5.60
Subregional applied research stock per capita	ln (*ARES*)	0.113	3.69
Regional basic research stock per capita	ln (*BRES*)	−0.019	−1.51
Budgeted share of research time	ln (*SR*)	0.344	2.74
Ph.D. degrees earned in agriculture and forestry per full-time equivalent researcher	ln (*APHD*)	−0.037	−1.52
Ph.D. degrees earned outisde agriculture and forestry per capita	ln (*OPHD*)	0.057	2.95
State revenue per capita	ln (*REV*)	0.178	2.59
Coop membership per capita	ln (*COOP*)	0.090	2.94
(*CONC*) × ln (*AGOUT*)		−0.624	−2.41
(*LAR*) × ln (*ARES*)		−0.592	−2.17
D_{70}[a]		0.682	4.75
D_{60}		0.362	2.03
Constant		−1.283	−1.96
R^2			0.92

[a] D_{70} and D_{60} are dummy variables for the years of 1970 and 1960, respectively. The constant includes effects of the year 1965 and the proportion of small farms.

elasticity is positive. The conclusion concerning the price inelasticity of demand for agricultural research was derived by comparing the signs of the estimated reduced-form coefficients with predicted signs of reduced-form coefficients based upon hypothesized values of structural coefficients and of the price elasticity of demand for research.

The positively and statistically significant coefficient of agricultural output is consistent with our hypothesis that the demand for agricultural experiment station research is positively related to the size of agricultural output. The negative coefficient on the *AGOUT-CONC* interaction variable implies that the elasticity of research expenditures with respect to output is reduced (increased) as a state's agricultural commodities become more concentrated (diverse). This result supports the hypothesis of commodity specificity of research final products. The elasticity of research expenditures with respect to agricultural output, evaluated at the sample mean of *CONC*, is 0.18. Although this estimate may seem small, the estimated coefficient of ln (*AGOUT*), is an estimate of the net effect of several different structural parameters (see appendix). The results imply that larger agricultural output shifts rightward the demand for research, but the exact magnitude of the shift cannot be determined. The elasticity of research expenditures with respect to *CONC*, evaluated at the mean of ln *AGOUT*, is negative. We hypothesized that greater diversity (concentration) of agricultural output would shift the demand for research to the right (left) and the supply schedule upward (downward). The negative elasticity is consistent with this hypothesis.

The size distribution of farms and the tenure status of farmers affects research expenditures through the demand and allocation equations. Expenditures are positively related to the proportion of large farms and to the proportion of medium-sized farms. (We find that variables measuring the size of farm output per capita

and the proportion of farms by size class are a superior specification to the number of farms per capita in each size class.) These directional effects are consistent with the positive hypothesized effects of these variables on the demand for research and on state revenue allocation. The marginal effect of *LARGE* on research expenditures depends on the size of the subregional applied research stock. The estimated coefficient of the interaction term between *LARGE* and ln *ARES* is negative. (When the interaction term between *LARGE* and ln *ARES* is excluded from the regression, the estimated coefficient of *LARGE* is positive but has a *t*-ratio of only 1.0. The estimated coefficient of an interaction between *MED* and ln *ARES* was not significantly different from zero at the 5% level.) It suggests that operators of large farms have greater ability to borrow (or have a greater incentive to search and experiment with) applied research from the available stock in similar subregions outside their state than have other farmers. This opportunity to borrow reduces their demand and willingness to lobby for indigenous applied agricultural research. At the sample mean value of ln *ARES*, the estimated percentage change in research expenditures due to a one percentage point change in the share of large farms is 0.80. Since the estimated coefficient of *MED* is 0.46 (not significantly different from zero at the 5% level), a one percentage point increase in the share of large farms (*LAR*) has a much larger effect on research expenditures than does a one percentage point increase in the share of medium-sized farms. This finding is consistent with differences in expected returns from indigenous agricultural research by these sizes of farms. The estimated coefficient of the proportion of farm owner-operators has the expected positive sign.

The positive and statistically significant estimated coefficient of the hired farm wage rate is consistent with the hypothesis of input prices shifting rightward the demand for indigenous applied agricultural research. The result suggests that farmers in states with high farm wage rates have demanded research to reduce the rising relative labor costs of agricultural production.

The information-related variables, except for farmers' education, have positive estimated coefficients. We hypothesized that both the demand for and the supply of research would be shifted to the right by extension activities. The positive coefficient is consistent with this hypothesis. The number of research centers per farm has a significant positive effect on research expenditures. Although this variable was expected to shift the research demand schedule to the right, the supply of research might shift in either direction, so the positive coefficient is consistent with our hypothesis. The negative and statistically significant coefficient of farmers' education is puzzling. We hypothesized that increasing farmers' education shifts rightward the demand for indigenous research and increases desired research expenditures. The estimated coefficient does not support this hypothesis. The result has the surprising implication that farmers' education substitutes for public sector indigenous research. This might arise from more educated farmers depending more heavily on private sector research (and less on public sector validation) or on borrowing large amounts of applied research from other states. The estimated coefficient of an education-applied research interaction term, however, was not significantly different from zero.

The performance of the variables measuring the potential research stock outside a state shows that external factors affect a state's research expenditures. The positive and statistically significant coefficient of subregional applied research suggests rivalry; applied research in similar subregions outside a state is competitive. A state's farmers demand indigenous research in an attempt to minimize their loss of comparative advantage to other farmers in similar subregions. The negative coefficient of regional basic research suggests that states with a greater potential for borrowing research reduce their expenditures on research. This can arise from a rightward shift in the supply of research, provided the demand for indigenous research products is price inelastic.

The budgeted share of research time and the two Ph.D. variables are supply-side control variables. Expenditures on research are positively related to the share of research time of station research staff. Raising the share of a researcher's time allocated to research may either raise or lower efficiency (the supply curve of research). If the demand for research is price inelastic, then the positive coefficient implies a loss in efficiency.

Expenditures on research are negatively (but not significantly) related to the station Ph.D.-to-researcher ratio. Research expendi-

tures are positively related to the number of Ph.D. degrees earned in areas other than agriculture and forestry within universities associated with agricultural experiment stations. The size of these Ph.D. programs provides an index of the quality of the graduate program in nonagricultural areas and the potential for intra-university borrowing of knowledge by station faculty and graduate students. When the demand for research is price inelastic, this positive coefficient contradicts the hypothesis of an efficiency gain, but it might reflect the general willingness of the public to support all kinds of research at land-grant universities.

The estimated coefficient of state revenue is positive, and the revenue elasticity of expenditures is 0.18. Thus, other things equal, states with greater financial ability do spend more on experiment station research. This finding supports Schultz's observation (1971) that wealthier states spend more on agricultural experiment station research than do less wealthy states and Peterson's finding (1969) that expenditures on experiment station research are positively related to a state's level of nonfarm income.

The estimated coefficient of cooperative membership is positive and significantly different from zero. Membership in this type of farm organization seems to influence state appropriations for agricultural research. Multiple membership in cooperatives also seems to be a significant factor in explaining research expenditures, because alternative empirical definitions of the coop variable that removed some or most of the overlapping membership (e.g., volume of business) performed less well.

Implications and Conclusions

Our results show that agricultural experiment station research expenditures have been responsive to economic and institutional forces. Experiment station research has been substituted for farm labor in an era of rising wage rates. Undoubtedly, much of this research has been induced to develop labor-saving (augmenting) techniques. Likewise, the finding of positive effects of the proportions of large and medium-sized farms and of owner-operated farms on research expenditures suggests that these groups affect the nature of research undertaken. However, the support for station research by the operators of large farms declines if there is a large quantity of applied research available from similar subregions in other states.

The wealthier (based upon per-capita state government revenues) and more agriculturally oriented states (as measured by size of agricultural output per capita) have supported and will likely continue to support public agricultural research in the future (Schultz 1971). In an era of relatively declining federal support, the implications for agricultural research stations in less affluent and less agriculturally oriented states are rather pessimistic. Farmers in these states may encounter increasing comparative disadvantage relative to farmers in states with similar geoclimatic regions, if their competitiveness is not maintained by a flow of applied research products. Also, if these states are characterized by smaller-sized farming operations, the capacity of these farmers for borrowing final research products from other states is further reduced. Finally, if other states in similar geoclimatic regions are suffering similar economic fates, the potential for borrowing basic research will be reduced.

The supply side of our model includes some implications for the organization of the experiment station. Expenditures for research are positively related to the budgeted share of staff research time and to the number of research centers per farm and negatively related to agricultural Ph.D.s earned per full-time equivalent station researcher. Assuming the demand for agricultural research is price inelastic, these results suggest that decreasing nonresearch commitments of researchers and increasing the regional specificity of research within the state through more research centers will decrease productivity of the station. Increasing the ratio of graduate students to station researchers may actually increase productivity.

In periods of fiscal restraint and declining real resources due to inflation, directors may find it necessary to reduce expenditures and reallocate station resources. To the extent that they are not bound by institutional constraints, substituting less costly research assistants for scientists, reducing the share of research time per scientist, and consolidating the number of outlying research centers may both reduce resource needs and increase station productivity.

Past research has shown that improved information has a positive impact on the demand for new agricultural inputs. In this study we

find that extension expenditures have a positive effect on research expenditures, but that farmers' schooling has a negative effect. Extension aids in the dissemination of information and research final products and in the identification of farm problems needing research. This complementarity should not be overlooked by state legislatures, especially if the federal government implements reductions in both research and extension funding. Although the education result is troublesome, holding all other factors constant, it may indicate that better-educated farmers realize the pervasive nature of public research and attempt to capture the benefits through private agricultural research. Thus, they may engage in their own research or purchase privately supplied research inputs.

Cooperative membership has a positive effect on research expenditures. To the extent that coop membership is a proxy for membership in farmer-oriented public interest groups, these results suggest that, if a state's farmers are better organized (Guttman), they will have a stronger effect on state allocations to agricultural research. Our results also imply that the multiplicity of farmer membership in these public interest groups increases their effect on research expenditures.

Some of the key variables in our model are expressed in per capita units as opposed to total units. Because the impact of a state's population on experiment station size may be of interest, we used our results to derive the total expenditure elasticity with respect to a state's population, valued at the sample mean of concentration and proportion of large farms and holding per capita state revenue constant. The implied elasticity estimate is 0.85, implying that states with large populations have the larger stations, other things equal.

The impact of potential cutbacks in federal funding for state experiment stations is a concern of the agricultural research system. In our model, federal funds for experiment station research are included in the state revenue variable. For 1960, 1965, and 1970, federal funds for experiment station research averaged 0.09% of total state revenues, and the state revenue expenditure elasticity of research expenditures was 0.18. Thus, a 10% decrease in federal support for station research implies a 0.9% decrease in state revenue and a 0.15% fall in state expenditures on agricultural research. Our analysis implies that the adjustment for an experiment station in an average state would not be drastic, but the adjustment may be more severe for stations in states where federal funding of station research is a larger-than-average share of total state expenditures.

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Appendix

The Mathematics of the Reduced-Form Equation

The model of resource allocation for agricultural research contains a demand equation, a supply equation, a revenue allocation equation, and an expenditure identity. In $\log_e$ linear form, the model is as follows:

$$\text{(1)} \quad \ln Q = \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \delta \ln P,$$

$$\text{(2)} \quad \ln P = \beta_2 \ln X_2 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + s \ln Q + \theta_1 \ln A,$$

$$\text{(3)} \quad \ln E = \gamma_3 \ln X_3 + \gamma_5 \ln X_5 + \gamma_6 \ln X_6 + \theta_2 \ln A,$$

$$\text{(4)} \quad \ln E = \ln Q + \ln P,$$

where δ, s, α_i, β_i, θ_i, and γ_i are unknown parameters; and where Q is quantity of indigenous applied research; P, price of indigenous applied research; E, revenue for (expenditure on) indigenous applied research; A, entrepreneurial activity of the station director; X_1, variable(s) entering demand equation only; X_2, other variable(s) entering demand and supply equations; X_3, other variable(s) entering demand and allocation equations; X_4 variable(s) entering supply equation only; X_5, other variable(s) entering supply and allocation equations; and X_6, variable(s) entering allocation equation only.

Equations (1)–(4) are solved to obtain the reduced-form expenditure equation:

(5)

$$\ln E = \{\theta_2/[\theta_2(1 - \delta s) - \theta_1 (1 + \delta)]\}\{\alpha_1(1 + s) \ln X_1 + [\alpha_2(1 + s) + \beta_2(1 + \delta)] \ln X_2 + [\alpha_3(1 + s) - \frac{\theta_1}{\theta_2}(1 + \delta)\gamma_3] \ln X_3 + \beta_4(1 + \delta) \ln X_4 + [\beta_5(1 + \delta) - \frac{\theta_1}{\theta_2}(1 + \delta)\gamma_5] \ln X_5 - \frac{\theta_1}{\theta_2}(1 + \delta)\gamma_6 \ln X_6\}.$$

There are thirteen structural parameters in the six reduced-form coefficients of equation (5), so identification of these structural parameters would require buying a relatively large set of nonzero restrictions on the included structural parameters. This exercise is left to the interested reader.

Participation in Farm Commodity Programs: A Stochastic Dominance Analysis

Randall A. Kramer and Rulon D. Pope

The net benefits of participation in farm commodity programs are analyzed with a normative risk model based on stochastic dominance theory. Utilizing entire probability distributions of participation and nonparticipation net returns, the impacts of alternative program features and farm size are investigated. Small changes in program parameters are found to affect participation decisions. It also is demonstrated that farm size can influence participation choices.

Key words: commodity programs, risk, stochastic dominance.

The decision to participate in farm commodity programs has traditionally been a voluntary one. Under current legislation a farmer may elect to participate by fulfilling any set-aside requirements that are in effect. For example, in 1979, set-aside was required for wheat, corn, sorghum, and barley. Previous research on commodity programs has focused primarily on either (*a*) the impacts of the programs on supply response (Houck and Ryan, Just) or (*b*) the impacts of the programs on asset values (Boehlje and Griffin, Harris). The intent of this paper is to contribute to the understanding of the economic incentives facing a grower choosing to participate or not to participate in commodity programs by assessing the benefits (improved income or income stability) and costs (set-aside acreage). Though expected returns have been used in analyzing program participation decisions (Robbins), the purpose of this paper is to present a procedure to analyze participation utilizing the entire probability distributions of net benefits. Since there is ample evidence that farmers respond to risk as altered by commodity programs (Just), the need for including risk in studying participation is apparent. A normative risk model, based on stochastic dominance theory, is used to investigate the impact of alternative program features and farm acreages on the participation decision of California field crop farmers. The stochastic dominance model also is compared to the more restrictive mean-variance analysis. Particularly where skewness is altered by the program, it is argued that expected utility, using empirical distributions, is likely to be more appropriate and more illuminating for investigating program choices.

Commodity Program Features

The commodity programs under the Food and Agriculture Act of 1977 feature a dual price system utilizing loan rates and target prices. Loan rates are used in determining the value of crops for nonrecourse loans through the Commodity Credit Corporation (CCC). A program participant can place any amount of production in approved storage and receive a loan equal to the loan rate multiplied by the quantity of grain in storage. If the average market price falls below the loan rate, the participant can forfeit the stored crop in lieu of repaying the loan. Consequently, the loan rate generally places a floor under the commodity price for a participant.

Target prices are used in the determination of deficiency payments to producers. Deficiency payments are activated when the average market price of a commodity over a specified period falls below the commodity's

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target price. The difference between the target price and the higher of the average market price or the loan rate establishes the per unit deficiency payment for participants. The national loan rate, which is used in the determination of maximum deficiency payments, may differ from the loan rate encountered by a farmer obtaining CCC loans, because the latter loan rate is adjusted for regional conditions.

Deficiency payments are multiplied by a program allocation factor which is not known in advance by farmers. It is legislated to be between 0.8 and 1.0. Deficiency payments are made on program yields rather than actual yields. The program yields are established by Agricultural, Stabilization, and Conservation Service (ASCS) county committees.

To be eligible for price and income supports, farmers must satisfy set-aside requirements (if any). In general, the set-aside acreage must be devoted to conservation practices. Additional voluntary diversions are encouraged through extra payments. Farmers meeting set-aside requirements also are eligible for disaster payments. Disaster payments are made for prevented plantings and unusually low yields. For further information on the commodity programs, see Johnson and Erickson.

A farmer considering the participation decision must weigh the program benefits resulting from the nonrecourse loans, deficiency payments, and disaster payments against the program costs resulting from the set-aside requirements. Given the operational complexity of the commodity programs, the participation decision requires careful analysis. The variability and other moments of economic returns are important considerations in farm level decision making (Lin, Just). Moments other than the mean are likely to be especially relevant in farm program participation decisions, because of the alleged risk-reducing nature of the programs.

Motivation for Stochastic Dominance Analysis

The methods for analyzing optimal choices or eliminating inefficient choices for a class of risk preferences are numerous in theory, but relatively few in practice. The method most used for continuous choice efficiency analysis is quadratic programming (or MOTAD). Often the efficient set is reduced to a single optimum plan based upon the mean-variance model of Freund. Stochastic dominance is a popular tool for discrete choice efficiency analysis. It makes pairwise comparisons of probability distributions, F_i and F_j, from a finite set of choices in order to determine if one is inefficient and should be discarded from the efficient set. When there is a continuous mixing of returns on various crops (whole farm planning), dominance procedures must compare an infinite number of farm plans. As a result, little progress has been made toward developing a portfolio algorithm based upon dominance considerations. Though mean-variance analysis easily can accommodate whole farm planning, its propriety rests upon the validity of return distributions or decision maker preferences which consider only mean and variance. Levy and Markowitz have argued that increasing the complexity of the approximation in mean and variance of a general utility function may improve mean-variance results. Yet, the fundamental issue is the existence and magnitude of higher order moments.

For these and other reasons, proponents of expected utility analysis have been critical of mean-variance approaches except under normality. Though the quadratic utility function gives an expected utility function in mean and variance without assuming normality, it exhibits increasing risk aversion, a property which seems to have little empirical or theoretical support (see Pratt for a discussion). It seems reasonable to suppose that returns both in and out of the farms program are not normally distributed (or symmetric) because the program serves to reduce the probability of low income events.

A remaining issue concerns the importance of modeling the optimal farm plan. Stochastic dominance performs well when there is a finite, and hopefully small, number of crop choices (such as those delineated by field boundaries in irrigated agriculture). On the basis of a 1979 survey of California farmers, it appears that there was little recent change in crop configuration in response to government programs; that is, the participation decision was conditional on crop selection.[1] Even in

[1] A mail survey was sent to 826 California farmers in nine counties. Information was requested on participation behavior in 1978 and 1979. Most respondents either participated in both years or did not participate in both years. A small number (25) participated in only one of the two years. More than half of this group (52%) altered their acreage of program crops by less than 15%. In all cases there were no systematic changes across farms with similar endowments.

the area of California considered, a farm may have few production or marketing alternatives in the short run, when specialized machinery investments, contracts, and field configurations for irrigated agriculture are considered. However, one suspects that continuation of the programs would lead to systematic adjustments. Therefore, the decision whether or not to participate in the farm programs, given crop acreages, seems to have both positive and normative economic relevance. This suggests that the generality implied by expected utility and stochastic dominance may be applied easily.

Stochastic Dominance

Stochastic dominance allows the ranking of probability distributions for different classes of risk attitudes. Although the concept of stochastic dominance is relatively new, a rather extensive literature on the subject has emerged (see Whitmore and Findlay for a bibliography). Recently Meyer has generalized the stochastic dominance theorems. As the earlier results are special cases, only Meyer's conceptual framework will be presented.

Meyer's work depends on the Arrow and Pratt measure of local risk aversion, $r(x) = -U''(x)/U'(x)$, where, generally, x is income or wealth. While the sign of the second derivative of the utility function, $U''(x)$, indicates whether a decision maker is risk-averse $[U''(x) < 0]$ or risk prone $[U''(x) > 0]$, its magnitude provides no insight into risk attitudes. This is because $U''(x)$ is affected by linear transformations, although the utility function is not. The Arrow-Pratt measure avoids this problem. It is also important to note that any utility function can be written in terms of $r(x)$(Pratt).

Meyer considers the set of decision makers, $U[r_1(x), r_2(x)]$, with utility functions that satisfy

$$r_1(x) \leq -U''(x)/U'(x) \leq r_2(x) \text{ for all } x.$$

In other words, the degree of risk aversion at all points x lies between $r_1(x)$ and $r_2(x)$ for all agents in the set The convenience of Meyer's approach is that different sets of decision makers can be considered by varying the lower bound, $r_1(x)$ and the upper bound, $r_2(x)$. Since $r(x)$ is generally estimated, it is convenient to consider not only point, but interval estimates of $r(x)$ as well. Thus, $r_1(x)$ and $r_2(x)$ may be the upper and lower bounds of the interval. Also, given such a set of decision makers [or a single decision maker for whom we are uncertain of $r(x)$], it can be determined whether or not all persons in the group prefer one cumulative distribution, $F(x)$, to another one, $G(x)$, or are indifferent. If $F(x)$ is preferred to $G(x)$, $F(x)$ is said to dominate $G(x)$.

If $F(x)$ is preferred to $G(x)$ for all permissible $r(x)$, then it must be true that

$$\int_0^1 U(x)f(x)dx - \int_0^1 U(x)g(x)dx = \int_0^1 U(x)[f(x) - g(x)]dx > 0,$$

where $f(x)$ and $g(x)$ are probability density functions defined over the range of the random variable specified here as [0, 1]. Integrating the above by parts yields

$$\int_0^1 [G(x) - F(x)]U'(x)dx = E_fU(x) - E_gU(x).$$

If the above expression is minimized over $r(x)$ and is positive, then all decision makers for whom $r_1(x) \leq r(x) \leq r_2(x)$ prefer $F(x)$ to $G(x)$ [even the decision maker least prone to choose $F(x)$]. Thus, the problem can be cast in a control framework with $U'(x)$ as a state variable and $r(x)$ as a control variable as follows:

$$\underset{r(x)}{\text{Max}} - \int_0^1 [G(x) - F(x)]U'(x)dx,$$

subject to the equation of motion,

$$[U'(x)]' = U'(x)[U''(x)/U'(x)],$$

and the constraints on the control,

$$[-U''(x)/U'(x)] - r_1(x) \geq 0$$
$$[U''(x)/U'(x)] + r_2(x) \geq 0,$$

and the initial condition, $U'(0) = 1.0$.[2]

This problem minimizes the difference in expected utility between $F(x)$ and $G(x)$ with respect to $r(x)$. The solution to this problem determines whether $F(x)$ is preferred or indifferent to $G(x)$ for all decision makers in the class, $U[r_1(x), r_2(x)]$, for any specified $r_1(x)$ and $r_2(x)$. Meyer shows that this control problem is a "bang-bang" one; that is, the solution value of the control variable will be either the upper or lower bound. Finally, if $F(x)$ is preferred to $G(x)$, then it has been shown that the objective functional must be nonnegative.

[2] Meyer assumes that $F(x)$ and $G(x)$ have points of increase on a bounded interval taken for simplicity to be [0, 1], thus, the limits of integration. The initial condition is a harmless normalization necessary to ensure that a unique maximum exists.

Two special cases of Meyer's formulation can be considered by varying the risk-aversion bounds. First, if $r_1(x) = -\infty$ and $r_2(x) = +\infty$, then the set of agents includes all decision makers. The first degree stochastic dominance theorem states that for any two probability distributions, $F(x)$ and $G(x)$, the expected utility of $f(x)$ exceeds the expected utility of $g(x)$, if and only if $F(x) \leq G(x)$ for all x with strict inequality for at least one x. In other words, all decision makers will prefer $f(x)$ to $g(x)$, if and only if the cumulative function $G(x)$ lies everywhere above $F(x)$.

The second special case is when $r_1(x) = 0$ and $r_2(x) = +\infty$. In this case the set includes all risk-averse agents. The second degree stochastic dominance theorem states that for all risk-averse agents, the expected utility of $f(x)$ exceeds the expected utility of $g(x)$, if and only if

$$\int_0^1 [F(y) - G(y)]dy \leq 0$$

for all x, and $G \neq F$ for at least one x. In other words, if two cumulative distributions cross, $f(x)$ is preferred to $g(x)$, if and only if the area beneath $F(x)$ and to the left of x is less than the area below $G(x)$ and to the left of x for any x. An application of first, second, and third degree stochastic dominance to technology choice has been presented by Anderson.

Though the above description has utilized continuous probability density functions, it clearly carries over to cases of discrete distributions by a simple modification of the above results by identifying integration as an appropriate summation. Using Meyer's formulation, dominance results are obtained for decision makers whose preferences lie in a specified interval.

Meyer's more general approach allows the ranking of distributions that could not be ranked by previous stochastic dominance theorems, such as first or second degree stochastic dominance. In one simple algorithm, first degree, second degree or more general dominance efficient sets can be delineated. Without reference to an individual decision maker, suppose it were determined that participation was preferred to nonparticipation for all $r(x)$ in (.0000001, $+\infty$). This implies that nearly all risk averters (those with $r(x) > .0000001$) would participate. Yet, second degree stochastic dominance could not have given us this information. Thus, even without knowing the quantitative measure of $r(x)$, we could be reasonably sure that a risk-averse decision maker would prefer participation. By varying $r_1(x)$ and $r_2(x)$, the effects of the magnitude of risk aversion on choices can be studied (see Pope for further discussion of the advantages of Meyer's approach). Finally, as stated earlier, a second reason for interest in the interval approach is that it allows more robust analysis than when point estimates of $U(x)$ and $r(x)$ are given. This is because these functions generally must be estimated, and, hence, interval estimates may be more appropriate than point estimates.

Model and Data

A nonparticipant's net revenue, summed over K crops, can be expressed as

(1)
$$NR_{np} = \sum_{i=1}^{K} \{[(P_i - HC_i) \cdot Y_i \cdot A_i] - PHC_i\},$$

where P_i is the market price; HC_i, average variable harvest cost per unit; Y_i, yield per acre; A_i, the total number of acres; and PHC_i, total variable preharvest cost, all for the ith crop. In this analysis fixed costs are ignored as they are assumed not to affect the participation decision of an individual farmer in the short run.[3] Harvest and preharvest costs are separated because harvest cost is assumed to be stochastic, varying with yield.

The net revenue for a program participant growing K crops can be expressed as

$$(2)\quad NR_p = \sum_{i=1}^{K} \{[(P'_i - HC_i) \cdot Y_i + DFP_i + DSP_i] \cdot (A_i - PHC_i) \cdot (1 - S_i)\},$$

where P'_i is higher of the local price or local loan rate for the ith crop;

DFP_i is per acre deficiency payment, or

$$\text{Max}\ [(TP_i - NP_i), 0] \cdot (PY_i - DY_i) \cdot AF_i;$$

DSP_i is per acre disaster payment, or $a_i \cdot TP_i \cdot DY_i$;

[3] Throughout, we model the preference function over the distribution of net returns. Only empirical analysis can determine whether omitting wealth or consumption is important, since utility theory does not determine whether wealth, consumption, income, rate of return, loss, etc., are utility function arguments. For constant risk aversion, changes in wealth or fixed costs will do nothing to the ranking of preference over distributions. For decreasing or increasing risk aversion, such changes will alter boundary intervals. However, because the total risk-aversion range of interest is analyzed, the qualitative results will not be affected.

AF_i is program allocation factor (assumed fixed);
TP_i is target price;
NP_i is higher of the national average market price or national loan rate;
PY_i is program yield;
DY_i is disaster yield, or

$$\text{Max } [(b_i \cdot PY_i - Y_i), 0];$$

a_i is 0.50 for wheat and feed grains and 0.33 for cotton;
b_i is 0.60 for wheat and feed grains and 0.75 for cotton; and
S_i is set-aside proportion, all for the ith crop.[4]

Deficiency payments are not made if $(TP_i - NP_i)$ is nonpositive. Also, no disaster payments are made if $(b_i \cdot PY_i - Y_i)$ is nonpositive. Equation (2) says that a farmer will receive an amount equal to the higher of the market price or loan rate, plus any deficiency and disaster payments, minus harvest and preharvest costs, all multiplied by the amount produced. As indicated by equation (2) and the definition of P'_i, participation serves to truncate the lower portion of the price distributions. Thus, if the distribution of net returns is normal under nonparticipation, it is likely not normal under participation.

Using equations (1) and (2), the participation decision of a field crop farmer in California's San Joaquin Valley was considered. A representative farm for Kern County was constructed with the following crop mix: 340 acres of wheat, 180 acres of barley, 80 acres of sorghum, 200 acres of cotton, and 120 acres of alfalfa hay.

In order to construct empirical probability distributions of net revenue, average Kern County prices and yields 1969–78 were used. While various government programs likely impacted on historical prices over this time period, the series of counterfactual prices would be difficult, if not impossible, to construct. Acknowledging this limitation, historical prices were used to construct the distributions. The probability distributions of prices and yields were considered independent. Empirical support or refutation for this assumption is difficult to obtain since farm level data are not available. However, support is indicated by low, and generally insignificant, correlation coefficients between prices and yields even at the county level.

Prices were deflated by the USDA index of prices paid for production expenses in order to adjust for inflation. The yield data were detrended with the following procedure. The data were regressed on time, and if the resulting coefficient was significant at the 5% level, the data were adjusted. The adjustment was made by predicting the mean value for 1979, and then adding to this value the regression residuals for each of the ten time periods. For the yield data, cotton and wheat required detrending. None of the deflated price data required detrending. Because one does not expect autocorrelated structures for yields, it was not deemed necessary to use an autoregressive, moving average scheme to detrend the data. Regression results are available from the authors upon request.

County check yields were used as program yields for wheat and feed grains in the calculations. The check yields are used by ASCS county committees as guidelines for determining program yields for individual farms. The check yields were obtained from the California state ASCS office. County check yields were not available for cotton because program yields are based solely on actual yields adjusted for abnormal conditions. A cotton program yield for the representative farm was calculated by applying ASCS formulas to the county average yield data.

Cost data were obtained from the University of California Cooperative Extension Budget Generator. The budget generator was used to synthesize costs for growing the various acreages of the five crops given above.

The upper and lower bounds on the risk aversion coefficients used in this analysis are shown in table 1. A negative value of $r(x)$ indicates risk proneness, a zero value indicates risk neutrality, and a positive value indicates risk aversion. Group 1 would include the most risk-preferring farmers, while group 12 would include the most risk-averse farmers. Little is known about farmers' risk characteristics, because very few utility functions

[4] Net revenue is multiplied by $(1 - S_i)$ to reflect the opportunity cost of the set-aside. If income-producing activities were allowed on the set-aside acreage, then the opportunity cost would have to be adjusted accordingly. However, under current provisions, no haying or growing of other crops is allowed on set-aside acreage. Also, this equation assumes that the participant's land is homogenous. If some of the land is of marginal quality, the opportunity cost would be reduced. Moreover, this equation does not consider all aspects of the participation decision, i.e., prevented plantings, diversion payments, use of nonrecourse loans for operating capital, and farmer-owned reserves. The farmer-owned reserves is a separate program beyond the scope of this study.

Table 1. Risk-Aversion Coefficients

Farmer Groups	$r_1(x)$[a]	$r_2(x)$[b]
Group 1	−0.04000	−0.03000
Group 2	−0.03000	−0.02000
Group 3	−0.02000	−0.01000
Group 4	−0.01000	0.00000
Group 5	0.00000	0.00125
Group 6	0.00125	0.00250
Group 7	0.00250	0.00500
Group 8	0.00500	0.00750
Group 9	0.00750	0.01000
Group 10	0.01000	0.01500
Group 11	0.01500	0.02000
Group 12	0.02000	0.03000

[a] Lower bound on the risk-aversion coefficient.
[b] Upper bound on the risk-aversion coefficient.

have been estimated for farmers (for a review of the measurement of farmers' risk preferences see Young et al.). The values in table 1 were selected so as to cover the range of risk-aversion coefficients reported in previous studies. If one assumes that the certainty equivalent is to surpass the lowest observation 90% of the time, then most decision makers would be in the lower portion of the risk-averse range (positive but close to zero) for constant risk-averse bounds and using most of the distributions studied. For this reason not all intervals were chosen to be of equal length.

The participation decision was analyzed by computing probability distributions of net returns for the representative farm based on the distributions of prices and yields, the synthesized cost data, and the 1979 target prices, loan rates, and set-asides. The program allocation factor was not known in advance by farmers, so the legislated minimum of 0.8 was used initially. The loan rate was assumed to truncate the price distribution in such a way as to stack all of the truncated probability at the loan rate. This is the truncation procedure used by Boehlje and Griffin. Target prices, loan rates, and costs also were deflated by the USDA index of prices paid for production expenses. The generated sample of net returns is given in table 2.

In order to assess the impact of program parameters on the participation decision, four alternative policy scenarios were examined. First, set-aside requirements were reduced by one-half. Second, target prices were increased 10%. Third, loan rates were increased 10%. Fourth, the program allocation factor was raised 10%. It was expected that each of these

Table 2. Generated Sample of Net Returns

	Probability Distributions									
Year	1	2	3	4	5	6	7	8	9	10
1969	22,639	29,871	31,828	37,536	26,875	31,131	24,142	36,472	48,956	62,991
1970	26,987	33,856	35,754	41,414	29,966	35,078	31,895	44,720	57,655	70,962
1971	30,869	32,590	34,843	39,087	32,590	33,166	36,482	38,110	65,477	68,480
1972	52,938	50,474	53,310	57,467	49,636	50,874	61,915	65,681	109,480	104,122
1973	68,373	63,666	66,019	63,666	63,666	63,666	98,222	96,090	140,357	130,514
1974	90,711	80,787	85,749	82,525	80,787	80,787	102,343	97,757	185,035	164,757
1975	73,913	67,471	70,692	67,471	67,471	67,471	97,842	94,886	151,384	138,069
1976	88,470	82,379	85,499	84,582	82,379	82,394	129,538	126,744	180,542	167,930
1977	44,854	46,858	48,876	51,220	46,858	47,466	68,461	69,467	93,326	96,905
1978	17,245	20,511	21,983	24,088	20,511	20,766	16,627	23,876	38,324	44,361

Note: The empirical distributions were calculated in the standard way of associating with each sample point the probability of 1/10. This was done for the ten scenarios described below:

1. Nonparticipation
2. 1979 program features
3. Set-asides cut by ½
4. Target prices raised 10%
5. Loan rates raised 10%
6. Allocation factor raised 10%
7. Nonparticipation with different cropping pattern
8. 1979 program features with different cropping pattern
9. Nonparticipation with acreages of all crops doubled
10. 1979 program features with acreages of all crops doubled

Program parameters were obtained from ASCS. Cost data were calculated by the University of California Cooperative Extension Budget Generator. All yield data except alfalfa came from California Crop and Livestock Reporting Service (1977, 1979). Alfalfa yields came from Kern County Agricultural Commissioner. All U.S. price data came from U.S. Department of Agriculture. Kern County barley and wheat data were obtained from Federal-State Market News Service (a). Kern County alfalfa prices came from Federal-State Market News (b). Kern County cotton prices were obtained from Kern County Agricultural Commissioner. The figures given are in 1967 dollars.

four scenarios would increase the incentives for participation.

Once the probability distribution for a participant was computed, it was compared to the distribution of a nonparticipant using a program written by Meyer to implement his theoretical formulation. The participation distribution was compared to the nonparticipation distribution for each of the policy alternatives. In addition, Meyer's program was used to rank the probability distributions of net returns for nonparticipation versus participation for two different farming situations. In one case, the sensitivity of the results to the cropping pattern was examined by parameterizing the acreages. The acres of non-set-aside crops (cotton and alfalfa) were doubled, and the acres of set-aside crops were reduced in a proportional way so as to keep total acreage constant. The other case assessed the effects of farm scale by doubling the acreage of all crops.

Results

The results of comparing the probability distributions of net returns for a nonparticipant and a participant are shown in table 3. A "1" indicates that nonparticipation is preferred for the corresponding utility group. A "0" indicates that neither distribution dominates. A "−1" indicates that participation is preferred.

The entries in row 1 show the rankings for nonparticipation versus participation under 1979 program features. Within the risk-preferring range (utility groups 1–4), nonparticipation dominates for all of the groups. Within the risk-averse range (groups 5–12), the results indicate a mixture of participation and nonparticipation, with program participation preferred by the more risk-averse groups. As table 2 indicates, program participation reduces the probability of both high and low income events such that second degree stochastic dominance does not occur. Rows 2 and 3 of table 3 show that cutting set-asides or raising target prices increases the number of utility groups preferring participation since these changes reduce the probability of low income events. In both cases all risk averters choose to participate.

The impact of raising the loan rates, as shown in row 4, is surprising. The results indicate that fewer utility groups would choose to participate. This can be explained by a reexamination of equation (2). Notice that an increase in the loan rates has two contrasting effects on a program participant's net revenue. Raising the truncation level of the local market price distribution increases the mean of the probability distribution of per unit market revenue, P'_i. It also reduces the mean of the probability distribution of per unit deficiency payments, $TP_i - NP_i$, since the program defines NP_i as the higher of the national average market price or national loan rate. The results indicate that with the particular price distributions used in this analysis, the reduction in stochastic deficiency payments outweighs the increase in stochastic market revenues resulting from higher loan rates. Again, large and small outcomes are truncated by the program. In fact, the probability of falling below $85,000 is 1.0 under the program and only 0.8 with nonparticipation. However, raising the loan rate increases the likelihood of low incomes

Table 3. Stochastic Dominance Rankings

	Utility groups											
Nonparticipation versus:	1	2	3	4	5	6	7	8	9	10	11	12
1. 1979 program features	1	1	1	1	1	1	1	0	−1	−1	−1	−1
2. 50% cut in set-aside	1	1	0	−1	−1	−1	−1	−1	−1	−1	−1	−1
3. Target prices raised 10%	1	0	−1	−1	−1	−1	−1	−1	−1	−1	−1	−1
4. Loan rates raised 10%	1	1	1	1	1	1	1	1	1	1	0	−1
5. Allocation factor raised 10%	1	1	1	1	1	1	0	−1	−1	−1	−1	−1
6. 1979 program features and different cropping pattern	1	1	1	0	−1	−1	−1	−1	−1	−1	−1	−1
7. 1979 program features and doubled farm size	1	1	1	1	1	1	0	−1	−1	−1	−1	−1

Note: A "1" indicates nonparticipation is preferred and a "−1" indicates a preference for program participation. A "0" indicates that the group is not unanimous in its ranking; some would prefer participation while others would not. The rankings are for returns in thousands of dollars.

when comparing the 1979 program distribution with the distribution with an increased loan rate.

As noted above, the value of the allocation factor was not known in advance by farmers. It was legislated to be between 0.8 and 1.0, so the most conservative assumption of 0.8 was used in the preceding analysis. Clearly, the qualitative effect of raising the allocation factor is known a priori: participation becomes more attractive. In row 5 the quantitative effect of an increase in the allocation factor to 0.9 is that one additional utility group prefers participation. This higher value could reflect a legislated change or more optimistic expectations by decision makers.

Row 6 of table 3 shows the rankings of nonparticipation versus participation with a different mix of crop acreages. The acreages of cotton (a program crop with no set-aside requirement) and alfalfa were doubled, and the acreages of set-aside crops were reduced. With the lower opportunity cost of participation from less set-aside, four additional utility groups choose participation.

The effects of farm scale are demonstrated in row 7. In this case all acreages were doubled. In comparison with the smaller farm with the same crop proportions operating under 1979 program features (row 1), one additional utility group participates. As earlier, the program serves to reduce low and high income events. This makes the participation distribution function begin to the right of the nonparticipation function and possess greater slope. Because this reduces the evaluation of low probability events more than high probability events, risk averters find participation more attractive for the larger farm. This suggests that there may be greater participation incentives for larger farms.

To put these results in perspective, it is of interest to examine actual participation behavior. In 1979 the percentage of ASCS California acreage enrolled in wheat and feed grains programs was 16.0 as compared to a national figure of 38.9. (U.S. Department of Agriculture 1980). The breakdown by crop in California was 20.7 for wheat, 18.4 for barley, 6.3 for corn, and 5.2 for sorghum. There was no set-aside and no enrollment requirement for cotton. Clearly, a majority of the California acreage was not enrolled in the programs. This data, of course, pertains to a wider variety of farm situations than the representative farm used in this analysis. Rows 1, 6, and 7 of table 2, based on 1979 program features, indicate a mixture of participation and nonparticipation depending on individual risk attitudes. The relative proportion of farmers in the participating and nonparticipating groups cannot be determined, given the small number of individuals for whom risk preferences have been elicited. However, there is nothing in the results presented here that contradicts observed behavior.

Expected Utility and Mean-Variance Analysis

The mean, standard deviation, and skewness of net returns for the various acreages and program alternatives are shown in table 4. As can be seen, it would not be possible to use mean-variance efficiency analysis to rank the nonparticipation distribution (row 1) relative to the participation distribution (row 2) under the 1979 program for the representative farm. This is because participation would result in a lower mean as well as a lower variance. This result also holds for the representative farm under the higher loan rates and allocation factor, and for the larger-scale farm under the 1979 features. This yields support for the use of the more general framework, stochastic dominance, in efficiency analysis; i.e., probability distributions that cannot be ranked in a mean-variance framework can be ranked by stochastic dominance, and the quantitative effects of risk aversion can be studied.

For the other situations shown in table 4, program participation reduces the variance of returns as well as increases the mean. For these situations, if mean-variance analysis were conducted (e.g., assuming normality), the distributions could be ranked for risk averters (groups 5–12), but not for risk preferrers (groups 1–4).

Skewness values are reported in table 4. In every case the net returns' distributions are positively skewed, suggesting that the use of a symmetric distribution function, such as a normal one, may be inappropriate. Note, however, that the skewness measure in some cases is not altered greatly by program enrollment, cf. 1 and 2 of table 4. This is because, for some crop configurations, program enrollment eliminates both high and low returns in program crops in a symmetric fashion.

Although mean-variance efficiency analysis cannot be used to rank nonparticipation ver-

Table 4. Mean, Standard Deviation, and Skewness of Net Returns

Alternatives	Mean	Standard Deviation	Skewness
1. Nonparticipation	51,700	26,019	0.234
2. 1979 program	50,846	20,808	0.220
3. 50% cut in set-asides	53,845	21,596	0.239
4. Target prices raised 10%	54,906	18,926	0.134
5. Loan rates raised 10%	50,074	21,464	0.223
6. Allocation factor raised 10%	51,280	20,486	0.208
Alternative crop mix			
1. Nonparticipation	66,747	36,948	0.189
2. 1979 program	69,380	31,958	0.261
Larger-scale farm			
1. Nonparticipation	107,054	51,979	0.236
2. 1979 program	104,909	41,564	0.222

Note: Skewness calculations were computed with the following formula:

$$\frac{\left\{\left[\sum_{i=1}^{N} x_i^3 - 3\bar{x}\left(\sum_{i=1}^{N} x_i^2\right) + 3\bar{x}^2\left(\sum_{i=1}^{N} x_i\right)\right] \Big/ N\right\} - \bar{x}^3}{\left\{\left[\left(\sum_{i=1}^{N} x_i^2\right) - N\bar{x}^2\right] \Big/ (N-1)\right\}^{3/2}}$$

sus participation under 1979 program features, one can still use a Freund utility function (which assumes normality) to calculate the breakeven level of risk aversion for participation. This would be the degree of risk aversion at which a decision maker would be indifferent between enrolling or not under an assumption of normality of returns. The difference in expected utility between participation and nonparticipation can be expressed using the mean and standard deviation values of table 4. The difference set to zero can be solved for the breakeven level of risk aversion and compared with the more general analysis of table 3. Since the alternative crop mix comparison involves a relatively large change in skewness, it may yield a striking contrast. The breakeven based on Freund's function is found to be -0.0153; yet the results of table 3 suggest that the expected breakeven point is in the interval $(-0.01, 0)$. Given the orders of magnitude usually thought of for $r(x)$, this represents a considerable difference. This serves to caution use of mean-variance analysis and indicates that crop mixtures may substantively alter the family of the distribution of returns and the implied indifference point between choices.

Conclusion

Using historical data, this analysis shows that risk attitudes may affect the participation decision; however, subjective beliefs also are important. Subjective probability distributions vary widely across farmers. Results from analysis based on elicited subjective distributions not reported here indicate that participation choices are quite sensitive to farmers' expectations; those who are more pessimistic about prices and yields are more likely to participate. The distribution of participation choices among farmers will depend jointly on their subjective probabilities and risk attitudes. In this analysis, historical prices and yields have been used, because it is hoped that even with aggregation errors they represent the central tendency of aggregated subjective distributions.

It is always difficult when using the representative farm approach to ascribe the results to a wider group; what has been presented is not presumed to represent the choices of all California or even all Kern County farmers. Rather, the intent has been to illustrate how changes in program parameters can affect program participation decisions, given varying attitudes toward risk. For example, increasing the loan rate, *ceteris paribus*, suggests fewer program participants.

This analysis shows that stochastic dominance is a useful method for analyzing the impacts of policy changes on program choice and for aiding in decision making at the micro level. Extension personnel could easily adapt

the model to specific farm situations by inserting relevant crop acreages, cost figures, and subjective probabilities on prices and yields as a natural generalization of computer-budgeting procedures. Given a rough estimate of risk preferences (for example, using the modified von Neumann-Morgenstern reference contract approach, which can be measured easily by lotteries on cassette), the approach here could delineate the efficient choice for an individual. Hence, stochastic dominance needs further consideration as a practical and inexpensive tool for decision making under uncertainty at the farm level.

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Notes

The Land Grant Colleges and the Structure Issue

Don Paarlberg

Recent writers have documented the fact that American agriculture is becoming industrialized. The earlier delineation into farm and nonfarm sectors is being blurred. Agriculture is losing its uniqueness; farmers are entering the main stream of economic, social, and political life. The agrarian tradition is in retreat. The family farm as an earlier generation knew it is rapidly vanishing. Numerous writings quantify these trends; for examples, see Lewis, Lin, Madden, Miller, Penn, Schertz, Senate Committee on Agriculture, University of Illinois, and U.S. Congress.

Some people look at these trends as being, on balance, good. Others consider them to be bad. Still others think of them as a mixture of good and bad. There is a division of opinion as to whether the trends are inexorable or whether they might be changed by public policy. Thus has arisen what has become known as "the structure issue."

The issue was lifted up by what became known as the "Hard Tomatoes Report" (Hightower). This publication alleged that the Land Grant College system had become subservient to agribusiness concerns. Various activist groups expressed concern about the deportment of the Land Grant Colleges, alleging that they showed preference for the large farmers. There were also charges with respect to environmental concerns, consumer issues, and the like. In 1979, Secretary Bergland brought matters to a head with a "dialogue on farm structure," a series of public hearings throughout the country.

For the purpose of this article, J. B. Penn's definition of structure is accepted. According to Penn, structure involves the following components: organization of resources into farming units; size, management, and operation of these units; form of business organization, whether a sole proprietor or several individuals in a partnership or corporation; the degree of freedom to make business decisions; the degree of risk borne by the operator; the manner in which the firm procures its inputs and markets its outputs; the extent of ownership and control of resources that comprise the farming unit; the ease of entry into farming as an occupation; and the manner of asset transfer to succeeding generations.

The structure issue presents the Land Grant College system with unsought and difficult questions. What has been their role in the emergence of these trends? How should they position themselves with regard to the current and prospective dialogue on these matters?

The thesis of this article is that the Land Grant Colleges, with their experiment stations, their extension services, and their classroom teaching, are operating to a considerable degree on the basis of two assumptions—implicit rather than explicit—made many years ago; that these assumptions have been called into question by the dialogue on structure; and that the Land Grant College system will have to reconsider these assumptions and decide whether to defend or revise them.

The two implicit assumptions are:

(a) that research and education are structurally neutral, and

(b) that technology is socially neutral.

These assumptions of neutrality are not embraced universally within the Land Grant College system, of course, but they are accepted widely enough so that they have contributed strongly to rhetoric and policy. The assumptions go back a long way and carry up to modern times. They are evident in the mood and tone of the report submitted by the Commission on Country Life, a seminal work. They are implicit in *A National Program of Research for Agriculture* (USDA-NASULGC) and in *Inventory of Agricultural Research, FY 1969–70* (USDA 1970). The Extension Service reflects these implicit assump-

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tions. Witness, *A People and a Spirit* (Colorado State University 1976) and *Extension's Commitment to People* (Vines and Anderson). The Extension Service recently modified somewhat its assumption of social and structural neutrality in its publication *Evaluation of Economic and Social Consequences of Cooperative Extension Programs* (USDA 1980). That the Land Grant Colleges have been reluctant to see the structure question raised is evidenced by their lack of enthusiasm for the national dialogue on this issue.

The assumptions that the consequences flowing from research and education were technical and economic rather than structural or social had considerable validity—and credibility—when they were first embraced 100 years ago. But, as the transformation of agriculture has proceeded, both their relevance and their acceptance have eroded. I propose to examine each of these implied assumptions, its validity, and its amenability to change.

Are Research and Education Structurally Neutral?

The Land Grant Colleges are a product of agrarian philosophy, which postulated the family farm as a uniquely valuable institution. The original intent was to make the family farm more efficient and thus more profitable. Research and education were the chosen means by which to achieve this objective.

Beyond doubt, the research and educational activities of the Land Grant College system were instrumental in helping make American agriculture the most efficient food producer the world has ever seen. In 100 years farming advanced from its traditional pattern to its present highly sophisticated form. The food supply increased in volume, improved in variety, and diminished in relative cost. Benefits were shared among various sectors of the society. Earl Heady has said: "The United States has had the best, the most logical, and the most successful program of agricultural development anywhere in the world" (p. 107).

That research and education might have the long-run effect of helping transform agriculture into something like an industrial enterprise was not envisioned by those who founded the Land Grant College system. But this is indeed what happened. Responsibility for this transformation must be shared, of course. Involved were not only publicly supported research and education, but privately supported initiatives of this same kind, plus farmer decisions, agribusiness ventures, and government programs of various types.

As the nature of modern agriculture began to emerge, the Land Grant Colleges found themselves in a dilemma. What was their position on structural change? What were they trying to do? Were they trying to preserve the traditional family farm? Were they trying to make agriculture over in accordance with an industrial pattern? Public espousal of either of these two positions would be dangerous. Preservation of the family farm in anything like its original form would mean shutting down most of the experimental and educational activity and jeopardizing the food supply. On the other hand, frank endorsement of an industrialized agriculture would imperil traditional support.

So, understandably, the Land Grant College system implied that it was structurally neutral. In their publications and in their appeals for funds, the research and education people confined themselves to technical and economic matters. The profound structural and social changes which agriculture was experiencing were presumed to have other origins. The posture was essentially this: The business of the Land Grant College system was to help farm people improve their methods so as to become more efficient, a noncontroversial criterion conveniently endorsed by the economists. Research and education were offered to all who would respond. The mission was to improve technology, not to set up and pursue some idealized structural design. The emphasis was on microeffects; concerns for macroeffects were largely adjourned. Whatever structural pattern evolved from this setting was natural and unintended. In Nietzsche's phrase, it was "beyond good and evil."

This posture had credibility for the better part of a century. It served to screen off the Land Grant College system from ideological contention and from political battles. It helped induce farmers to accept individual responsibility for such good and bad experiences as they encountered.

But evidence has come before us that the Land Grant College system, whatever its intent has served to speed the trend toward an industrialized agriculture. It simply has not been possible to make such great advances in efficiency as have occurred without having profound effect on the structure of agriculture.

The experiment stations, by conquering poultry disease, made it possible to grow thousands of birds in close confinement, thus transforming the broiler industry. The Extension Service, with its advice that a farmer should have a business "big enough to be efficient" undoubtedly speeded up farm consolidation and reduced the number of farms. In the classroom, emphasis on modern management helped put the traditional family farm into a state of near-total eclipse.

Medium and large farm operators have more contact with extension programs than do small farmers (USDA Jan. 1980, p. viii). What happens is this: the research and extension people make their offerings available to all, cafeteria style. The farmers who avail themselves of this help are generally the more alert, the more innovative, the more aggressive, the more politically astute, the socially dominant, the better managers of the larger farms. They select what is useful to them, in their circumstances. In the next round the research and education people, like good cafeteria managers, supply more of what moved best and less of what moved poorly. So, over time and without deliberate intent, the offerings are tilted toward the bigger, better, wealthier, and more innovative farmers. After several such rounds, even if the small farmer should come to the extension meeting, he would find little of value to him. The clientele is self-selected. There is no conspiracy, but the results are not greatly different from what they would be if there were. Thus, public-supported research and education accelerate the trend toward the industrialization of the food system and widen the income differentials within agriculture.

Supporters of research and extension contend that while the big operators are generally the early adopters, there is a "filter-down" effect; in time the smaller operators emulate the big ones. In earlier years, when agriculture was more homogenous, the "filter-down" effect no doubt was stronger than it is at present. For example, 40% of the hogs are now produced by year-round, low labor, capital-intensive confinement units selling more than 1,000 hogs annually. Among hog producers, they are the chief users of research and extension. Practices in use on such farms have limited applicability for farmers producing smaller numbers of hogs by traditional methods on a seasonal basis.

The side effects of research and education in agriculture are now being held up for examination. Most of the activists allege that the side effects are on balance adverse, but this has not been established.

In positioning itself with regard to this issue, the Land Grant College system faces a choice among alternatives:

(*a*) Leave the programs essentially unchanged while continuing to imply that research and education are structurally neutral. This is the wish of the larger farmers, who are the agricultural elite. But this posture becomes increasingly difficult to defend with passing time.

(*b*) Continue the programs much as they are and drop the facade that they are structurally neutral. Acknowledge that the Land Grant College System serves the needs of the better, bigger farmers and accelerates the trend toward an industrialized agriculture. Frankness argues for this; political expediency argues against it.

(*c*) Revise the programs so that they come closer to being structurally neutral, as is professed. Modify agricultural research, extension, and classroom teaching so as better to serve the needs of small, moderate-sized and part-time farmers. This appears to be the objective of those who raise the structure issue. But it is hard to do and is offensive to the agricultural elite.

(*d*) Some combination of the above.

One can readily sympathize with the Land Grant Colleges in having their facade of structural neutrality stripped away and being forced into so difficult a choice.

With a growing share of agricultural research and education now being provided privately or through nontraditional institutions, and with the trends toward industrialized agriculture having built up such great momentum, the choice among the alternatives may have more relevance to the structure of the Land Grant College system than to the structure of agriculture.

Is Technology Socially Neutral?

The Land Grant Colleges convey the inference that they are not only neutral with respect to the structure of agriculture; they also think of themselves as socially neutral. That is, they generally profess to be impartial in their service to various groups of farmers and they like to think that their activities do not basically alter the established relationships among

different individuals or groups in the society. They are staffed by scientists and technologists who work on improved methods of producing, processing, transporting, and merchandising food and fiber. The staffers contend that the primary result of their work is to improve efficiency without altering prevailing social or political patterns. Their graphic model of the relationship of advances in agriculture efficiency to the general benefit of the public is a line that is positive, linear, and steep. An efficiency gain is good, a larger gain is better, and the greatest gain that could be achieved would result in the greatest possible public benefit. In the conceptual models, social and political consequences of technological advance are impounded in "other things equal," or are labeled "side effects" and "externalities." Sometimes, of course, the conceptual model of social sterility is set aside to accept credit for a social development deemed worthy like the improved status for farm people, which undoubtedly has resulted from educational services provided by the system. But rarely is responsibility acknowledged for social developments that have a bad connotation. This straddle involves some difficulties, like taking credit for the hog but not the smell.

The assumption—implied rather than explicit—that technology is socially neutral has permitted the Land Grant College system to concentrate on its intended purpose, technological change. The socially elite have not felt threatened and the politically powerful have felt secure. Having thus reassured the establishment, the Land Grant College system was free to do its work with a minimum of harrassment.

But the evidence being lifted up by the dialogue on structure is that technology is not neutral. The modernization of cotton production in the South, in large part a result of work done by the Land Grant Colleges, displaced millions of people. Many of these people migrated to Chicago, Detroit, Cleveland, Washington, and New York, to a culture they understood poorly, in search of jobs for which they were not prepared. At least in the short run this was a difficult transition. Perhaps in the long run it will prove advantageous. This "side-effect," whether on balance good or bad, exceeded in significance the cost-lowering achievement of the research and education on cotton production, in my view.

The voluntary nature of the research and educational system resulted in nonservice to those who lacked the sophistication, the social status, and the political clout to obtain such service. The cost-lowering production-increasing practices adopted by the innovators reduced prices of farm products and put pressure on those who for various reasons could not or would not, or in any case did not, employ the new techniques. Many of these people and their children left agriculture. Undeniably, this had social consequences.

When the Land Grant College system was set up in 1862, 59% of our people were on farms. In part as a result of research and education supplied by the system, farms were enlarged and reduced in number, so that farmers now constitute less than 4% of the population. T. W. Schultz puts the actual outmigration from American farms during the years between 1930 and 1974 at 33 million people, the largest migration of modern times. One can argue at length as to whether so massive a change is good or bad. But it is not possible to argue convincingly that transformation from an agrarian to an industrial society is socially neutral.

Research has shown that the modernization of agriculture can have adverse effects on the social structure of rural towns and villages (Community Services Task Force Report). Other research has shown the pervasive social benefits of efficient food production (Heady).

The graphic model that describes the relationship of agricultural efficiency to the benefit of the public may not be positive, linear, and steep, as the Land Grant Colleges generally assume it to be. Instead, it may be a curve, reaching its apogee at some point short of imposing intolerable stress on the social fabric. Beyond that optimum point the curve may turn down, and if the pursuit of efficiency is carried too far, it may become negative. "Side-effects" may break out of the stockade within which assumption has sought to impound them. This is the model of the sociologist, the anthropologist, and the political scientist. These people are almost without representation in the Land Grant College system.

Whether there is such a curve and, if so, where we are on it are debatable subjects. But the assumption that technology is socially neutral is increasingly hard to defend. Who will deny that farm people were elevated socially when, through the Land Grant College system, their opportunities were increased? Who will contend that the outmigration from ag-

riculture of 33 million people was without social significance?

The most vivid examples of the nonneutrality of agricultural research and education, socially speaking, are to be found in overseas developmental programs. The surge of rural populations to the great cities, in part the result of agricultural development, is perhaps the most persuasive evidence that agricultural technology has social consequences. Agricultural development, based on research and education, is one of the most potent of social transformers. Whether the transformation is for good or evil depends on its components, its magnitude, its speed, its duration, and the manner in which it is perceived.

The alternatives facing the Land Grant College system regarding the social consequences of its programs are similar to those related to farm structure: (*a*) continue to imply that technology is socially neutral; (*b*) continue the existing programs and frankly acknowledge that they have social consequences, good and bad; (*c*) modify the existing programs, taking into account their social consequences; or (*d*) a mixture of the three.

The third alternative would involve changes in research. Some of the variables would be shifted from exogenous to endogenous form. Some "externalities" and "side-effects" would be moved into the model. Macro as well as micro forces would be taken into account. Some sociologists might be employed. We are beginning to do this for our overseas agricultural development programs, but have some difficulties in bringing ourselves to it for our own country.

Changes in the extension program also would occur. The present tilt in favor of the larger farms and high technology would be reduced. In a voluntary program, lacking central direction, it probably cannot be eliminated. Favorable social consequences of research and extension would be documented, and work would be expanded in these areas. Some resources would be directed to alleviating the adverse side effects of certain research and educational programs.

This would all be difficult. It would involve discarding the defensive armor that has, for 100 years, kept the Land Grant College system reasonably well-insulated from social and political strife. It would involve modifying the assumption that efficiency, in a micro sense, should be the decisive if not the sole criterion for agricultural change.

But the defensive armor is losing its effectiveness. The old postulates can no longer be insulated from those who question them. There may be no real alternative to revising the assumptions. If this is done, quite possibly the Land Grant Colleges would come, in time, to be pleased with the result. On the basis of newer and broader criteria, their programs might improve, and balanced public assessment of their net structural and social effect might well turn out to be positive. The Land Grant Colleges may have less to fear than they imagine.

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Composite Forecasting: An Application with U.S. Hog Prices

Jon A. Brandt and David A. Bessler

Producers, processors, and distributors of agricultural commodities make decisions in a risky environment. Uncertain production and relatively low price elasticities of demand provide the setting for rather large fluctuations in commodity prices. Sensible decision making thus requires information about the likelihood of many alternative outcomes. Such information can be obtained from both private and public sources through price forecasts.

Decision makers often have several forecasts on which to base their plans. They realize that alternative forecasting systems rarely give the same forecast. When faced with alternative forecasts of the same event, it is quite typical to attempt to discover which forecast is best. For example, Leuthold et al. considered alternative approaches to forecasting daily hog prices—time-series [autoregressive integrated moving average (ARIMA)] and econometric models. They concluded that the econometric model did slightly better than the ARIMA model over the evaluation period. At first glance, one might conclude that it is better to use the econometric model and refrain from using the ARIMA model. However, further study probably would reveal that each set of forecasts contains useful information which the other does not possess.

Indeed, this is the case illustrated in a study by Bates and Granger, where they considered two alternative models for forecasting monthly airline passenger mileage. While one of the models showed an overall superiority, their combined forecasts outperformed both individual forecasts. In fact, for an optimal combination of individual forecasts, it can be demonstrated that the combined forecasts will have an error variance not greater than the smallest error variance of the individual forecasts. Additional theoretical and empirical analysis by Johnson and Rausser, Granger and Newbold, and others have confirmed and extended the early efforts of Bates and Granger.

Forecasting Techniques

The justification for and empirical accuracy of several composite forecasting techniques based on the individual forecasts of econometric, ARIMA, and expert opinion methods are examined in this study. This will be accomplished, in part, by empirically evaluating the quarterly U.S. price forecasts for hogs through selected measures of performance. From these evaluations, forecasters and forecast users should have a clearer understanding of some of the advantages and limitations of individual and composite model forecasting.

Individual Models

Our objective was to develop an econometric price forecasting model for hogs which was relatively accurate and simple to understand, use, and update.[1] Consequently, a single-equation reduced-form model was formulated which included lagged supply and demand variables (with the exception of current income) that explained (predicted) movements in prices.[2] The following equation was estimated using ordinary least squares regression over the sixty-quarter period from 1961 through 1975:

$$(1)\quad \begin{aligned} PH_t = &-172.5056 - \underset{(11.14)}{8.5038}SF_{t-2} \\ &- \underset{(5.21)}{3.8707}SF_{t-3} - \underset{(4.99)}{3.9388}CS_{t-1} \\ &- \underset{(5.71)}{42.6470}HTCH_{t-1} + \underset{(16.76)}{47.5997}\ln Y_t \\ &- \underset{(7.30)}{44.7532}PKST_{t-1}, \end{aligned}$$

where $R^2 = .93$, $D.W. = 1.79$, PH is the quarterly weighted farm price of hogs, SF is the number of sows farrowing quarterly in fourteen states (millions), CS is U.S. commercial cattle slaughter (billion pounds), $HTCH$ is quarterly broiler-type poul-

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[1] Crowder and Cromarty and Myers have argued that a significant gap exists between the theoretical group of model builders and the user group who seek simplicity and judgment in solving problems. Chen, however, has suggested that this gap has been narrowing. In this analysis, simplicity and theoretical soundness were concurrent goals.

[2] Econometric models often have used current endogenous and current exogenous variables as regressands. This suggests that the forecaster must also generate predictions for the explanatory as well as the dependent variable. Such a procedure is likely to compound the forecasting errors. However, because income has been trending upward rather steadily, it was felt that little error would result in projecting its movement.

try eggs hatched (billion eggs), $\ln Y$ is the natural logarithm of quarterly disposable income (billion dollars), $PKST$ is pork cold (and cured) storage at the end of the quarter (billion pounds), and t reflects the quarterly period of observation. The figures in parentheses are the t-values of the coefficients. It appears that the single-equation model has performed reasonably well in explaining price movements. All coefficients are more than twice their standard errors. These coefficients were used to make the initial forecast for the first quarter of 1976 (7601).[3]

As an alternative to the structural econometric model, forecasts are possible by specifying prices as autoregressive integrated-moving-average (ARIMA) processes. Box and Jenkins suggest a three-step procedure for identifying the class of ARIMA models, estimating the parameter values of the identified model, and checking the appropriateness of the estimated model.

The identification procedures involve the comparisons of estimated autocorrelations and partial autocorrelations of the series of interest with the theoretical autocorrelation and partial autocorrelation functions of known ARIMA processes. Given a class of ARIMA models from the first stage, their parameter values can be estimated from the historical series using nonlinear least squares. Finally, the identified and estimated model can be checked by studying the behavior of the residuals.

These procedures were applied to the quarterly hog price series, resulting in the following ARIMA model:

$$(2) \qquad (1 - B)PH_t = (1 - .44B^5)e_t,$$

where B is the lag operator ($B^i PH_t = PH_{t-i}$) and e_t is a white-noise random disturbance. The chi-squared statistic associated with the estimated residuals of this model is well under the critical value at the 5% level of significance, which does not lead us to suspect the adequacy of the estimated model.

Another alternative to the quantitative models suggested above is expert opinion prediction. Universities, the U.S. Department of Agriculture, private forecasting firms, and others routinely generate forecasts. These are usually short-run in nature and are based on an understanding of the industry structure, seasonal production and consumption patterns, and international events that affect the commodity. In many respects, the forecasts of experts are like those of econometric or ARIMA model forecasts in that they incorporate information from similar data sources. Expert opinions, however, are less restrictive because the weights assigned to different bits of information can be changed with relative ease.

[3] The model was designed to allow for continuous update. Thus, new coefficients were estimated each quarter as new data became available. The magnitudes of these coefficients did not vary much from quarter to quarter, however.

Composite Models

Following Bates and Granger, one can recognize that most forecasts contain some information which is independent of that contained in other forecasts. Thus, a combination of forecasts will, quite often, outperform any of the individual forecasts. For convenience, the discussion here is limited to unbiased forecasts. Detecting and combining biased forecasts is discussed in another paper by the authors.

Three approaches used to combine the forecasts of the individual models described above are summarized here. (See Bessler and Brandt for more detailed development of these methods.) These involve different methods for choosing the weights assigned to each individual forecast. Two of the methods require an historical record of performance by the forecasting models. The first is a weighting scheme based on the sixty-quarter historical forecast period prior to 7601. The approach assumes the performance of each individual forecast method is consistent over the forecast period. Combining the forecasts of two methods results in the following weights:

$$(3) \qquad a_1 = \frac{\sigma_2^2 - \rho_{12}\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho_{12}\sigma_1\sigma_2}$$

$$a_2 = 1 - a_1,$$

where a_i is the weight assigned to forecast method i, σ_i^2 is the forecast error variance associated with method i, and ρ_{ij} is the correlation coefficient between the errors of forecasts i and j. This weighting scheme minimizes the variance of the forecast errors over the sixty-quarter historical period.

A second method involves an adaptive weighting scheme which allows the weights to adapt or change from period to period. It is based on the assumption that forecasting models may not have constant performance over time. Thus, weights can be constructed which reflect recent forecast errors more strongly than distant ones. The following expression can be used to determine weights for two forecast methods:

$$(4) \qquad a_{1,T+1} = \sum_{t=T-v}^{T} \frac{e_{2t}^2}{e_{1t}^2 + e_{2t}^2}$$

$$a_{2,T+1} = 1 - a_{1,T+1},$$

where $a_{1,T+1}$ is the weight assigned to forecast method 1 in period $T + 1$, e_{it} is the error made by forecast method i in period t, v is the choice variable which represents the number of periods included in the adaptive weighting procedure, and T is the total number of periods for which a history of forecast errors is available. Thus, only the errors for the last v periods are considered when assigning weights.

A third, rather simple, method for combining forecasts is simple averaging. Often, a user has several forecasts available but does not have a his-

tory of performance on each. Rather than arbitrarily basing decisions on one particular forecast, the user can combine all forecasts by averaging. This gives each forecast equal weight and involves relatively low calculation costs.

Forecast Results and Performance Evaluation

Individual Model Forecasts

Hog price forecasts were generated by each of the three individual methods over the fourteen-quarter period 7601 through 7902. These forecasts (and their associated mean-squared errors) presented in columns 2, 3, and 4 of table 1 can be compared with the actual prices in column 1. While this is not a long period over which to evaluate the performance of the forecasting techniques, it does serve as a starting point from which further updating and evaluation can be performed as new observations become available. In addition, these fourteen periods do provide a sufficient sample over which to generate composite forecasts.

The mean-squared error results suggest that among the individual methods, the ARIMA model performed substantially better than either the econometric or the expert opinion. In each of these latter two methods, a single, poor forecast (in 7604 for econometric and 7801 for expert opinion) sharply increased the mean-squared error statistics.

Table 2 indicates the accuracy of the models in tracking the movements of actual prices from period to period by cross-comparing the predictions of the forecast models with actual observations. If prices increased one period, then decreased the next, a change in the direction would be observed. Price increases two periods in a row suggest no change in direction. If an actual change were correctly forecast, the upper left-hand element in each 2×2 matrix would be increased. Similarly, if no change were predicted and observed, the lower right-hand element would be incremented. High numbers in these diagonal elements are indicative of high performance by the models. High off-diagonal numbers are indicative of poor performance.

The econometric model did a poor job in tracking the hog price series. In eight of the periods, the model predicted a change in the direction of the series when, in fact, none occurred. In only four of the periods did the econometric model correctly predict a change in the series. For the ARIMA and expert-opinion models, the tracking performances for the hog price series were considerably better. Both models accurately tracked the price movements in more than half of the quarters.

Composite Model Forecasts

Three methods of combining the forecasts of the individual econometric, ARIMA, and expert-opinion techniques are analyzed in this section. One approach incorporates the adaptive process [equation (4)] whereby the weights assigned to each

Table 1. Hog Price Forecasts from Individual and Composite Methods ($/Cwt.)

		Individual			Composite			
Period	Actual Prices[a]	Econometric	ARIMA	Expert Opinion[b]	Two-Period Adaptive[c]	Minimum Variance[c]	Simple Average[c]	Simple Average[d]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
7601	47.90	48.55	48.54	47.00	48.55	48.54	48.55	48.03
7602	49.15	46.64	49.05	48.50	46.82	48.55	47.84	48.06
7603	43.53	47.76	46.81	45.00	46.86	47.00	47.28	46.52
7604	34.16	43.71	39.12	35.00	40.53	40.06	41.41	39.28
7701	38.96	45.32	35.27	35.00	37.73	37.34	40.30	38.53
7702	40.76	44.82	39.24	32.50	40.50	40.39	42.03	38.35
7703	43.67	45.00	40.72	44.00	41.65	41.60	42.86	43.24
7704	41.30	47.84	45.12	37.50	46.14	45.68	46.48	43.49
7801	47.43	47.73	43.49	36.00	44.95	44.37	45.61	42.41
7802	47.85	48.01	45.80	42.00	46.71	46.25	46.90	45.27
7803	48.59	46.78	47.18	51.00	46.78	47.10	46.98	48.32
7804	50.03	52.08	47.28	45.00	50.42	48.27	49.68	48.12
7901	51.79	49.69	51.72	51.00	50.58	51.30	50.71	50.80
7902	43.07	51.01	50.05	48.00	50.50	50.25	50.53	49.69
Mean Squared Error		20.88	10.93	23.10	11.01	10.21	11.67	8.97

Source: Actual prices—USDA *Livestock and Meat Statistics* and *Agricultural Outlook*.

[a] Average of three monthly prices of barrows and gilts at seven combined markets, weighted by the monthly U.S. commercial hog slaughter.

[b] Expert opinion forecasts are based on monthly predictions by the Department of Agricultural Economics Marketing Guides Committee, Purdue University. See Bessler and Brandt for details regarding these forecasts.

[c] Composite of econometric and ARIMA methods.

[d] Composite of econometric, ARIMA, and expert-opinion methods.

Table 2. Turning Point Measures for Evaluating Individual and Composite Model Forecasts

Movements		Individual Models					
		Econometric		ARIMA		Expert Opinion	
		C	NC	C	NC	C	NC
Actual	C	4	2	4	2	4	2
	NC	8	0	3	5	4	4

		Composite Models[a]							
		Two-period Adaptive[b]		Minimum Variance[b]		Simple Average[b]		Simple Average[c]	
		C	NC	C	NC	C	NC	C	NC
Actual	C	3	2	3	2	2	3	3	2
	NC	3	4	2	5	3	4	4	3

Note: The measures indicate a change (C) or no change (NC) in the direction of the price movement, i.e., a prediction of turning points. Higher performance is associated with larger numbers on the positive diagonal of each 2 × 2 matrix.
[a] Because only fourteen expert-opinion forecasts were available, only twelve between-period comparisons were possible.
[b] Composite of econometric and ARIMA methods.
[c] Composite of econometric, ARIMA, and expert-opinion methods.

model vary over time, depending on the accuracy of the model over previous periods.[4] The second method combines forecasts based on a minimum variance criterion [equation (3)]. The third method averages the forecasts of the methods for each period (equal weight to each model).

The composite results based on the three methods of combining the forecasts of the individual techniques over the fourteen-quarter period, 7601–7902, are also presented in table 1. The adaptive (column 5) and minimum variance (column 6) processes used in weighting the forecasts require a history of predictions. Expert opinion forecasts prior to the 7601–7902 period were not available. Therefore, the adaptive and the minimum variance forecasts are a composite of only the econometric and ARIMA models. For comparison purposes, simple-average forecasts of these two methods are presented in column 7. Finally, composite forecasts using a simple average of all three techniques (econometric, ARIMA, and expert-opinion) are provided in column 8.

The adaptive-process forecasts are those which resulted in the minimum mean-squared error [for $\nu = 1, 2, \ldots, 60$ in equation (4)]. Combining the predictions of the econometric and ARIMA models of the two prior periods (i.e., $\nu = 2$) to determine the weights for the current forecast period generated the smallest mean-squared error of the sixty processes analyzed. The weights associated with the price forecasts from the adaptive process reflect this short error history. The actual weights assigned by the process to the econometric forecasts range from a high of .98 to a low of .01. [In examining two other livestock commodities in the study, the authors found a similar range of weights for the econometric method for cattle price forecasting, based on only a single prior period's errors ($\nu = 1$). In contrast, a more stable behavior of adaptive weights was noted in forecasting broiler prices, where an error history of nine periods generated the lowest mean-squared error (Bessler and Brandt).]

A comparison of the composite forecasts with those from the individual forecasting methods suggests that the MSE's from the three-method simple-average and the minimum variance method are slightly lower than the ARIMA MSE (table 1). Each mean-squared error of the composite forecasting methods is considerably lower than that of either the econometric or the expert opinion method. From the theoretical concepts supporting the composite forecasting approach, it would be expected that if two (or more) forecasting techniques were based on different information, the quality (MSE) of the forecast should be improved by combining them. The MSE performance criterion is consistent with this hypothesis.

Table 2 illustrates the ability of the composite forecasts to track the actual price movements. The composite forecasts accurately predicted the direction of the price movements in at least half of the periods. The results in table 2 suggest that the composite methods perform about the same as the individual methods for tracking price movements.

Perhaps the most significant argument that could be made for considering composite forecasts is that none of the composite forecasts performed as poorly as the worst of the individual techniques. This is particularly important to the user who has several sources of forecasts available to him. If the user has reason to believe that each is based on sound information and has no prior knowledge concerning its performance, he might select any of the three techniques and base his production and marketing plans on the forecasts of that particular

[4] The smallest number of observations (i.e., previous forecasts) used to generate weights was one; the largest number was sixty. In all cases, as a period was added, the most distant period was deleted.

method. Consequently, the user might accept unusually high risk if he based his plans on an inferior forecasting technique. The composite forecasts do not exhibit this same pattern. The mean-squared error of the best composite method (simple average of all methods) is only 86% of the mean-squared error of the best individual method (ARIMA). The MSE is the poorest of the composite methods (simple average of econometric and ARIMA models) is 50% of the MSE of the poorest individual method (expert opinion). Furthermore, if one does not know which set of forecasts to use based on a priori information, the riskiness of a large mistake is reduced by selecting the composite set.

Closer inspection of table 1 indicates that the mean-squared errors from the somewhat more sophisticated composite weighting schemes (adaptive and minimum variance) are lower than that of the simple average composite of the econometric and ARIMA models. This example shows that if a history of forecast performance of the models is available, the incorporation of this information through the weighting procedure can result in greater accuracy of the composite forecasts. However, note that as additional information is added to the set (in the form of expert opinions), the mean-squared error is reduced further (column 8).

Implications: Forecast Users

The analysis performed in this article has several implications to users of price forecasts. (*a*) Forecasts taken strictly from individual models are not likely to provide the user with the most accurate information for decision making. It was shown that large errors are likely in each of these models. (*b*) Even if the user has no prior performance record of the forecasting models, he might be advised to combine the forecasts from alternative models in a simple fashion (such as averaging) to remove the likelihood of making large mistakes based on the forecasts of a single model. (*c*) If prior forecasting performances of the models are available, the user could weight future forecasts of the alternative methods based on this past record. He will want to pay close attention to the relative performance of each model. Elsewhere the authors show that incorporating the prior performance of the individual model's forecasts, either through the minimum variance or adaptive process weighting schemes, results in lower mean-squared errors than those from simple averaging of price forecasts. A word of caution is suggested for users, however. Forecasts in this study were for a rather short period (fourteen quarters).

Forecasters

The results of the performance evaluation suggest that forecasters should seriously consider using composite forecasting techniques. The idea that alternative forecasting methods use a variety of different information sources and means for assimilating the information and generating forecasting is theoretically appealing. Empirically, the results of this study agree with those of earlier researchers confirming the usefulness of composite forecasting. It might be beneficial to both users and other forecasters to know if the forecasts available from various sources are composites or based on a single method.

Forecasting models must be evaluated in order for both the forecaster and the user to have confidence in the forecast. Alternative performance criteria were used to measure the performance of individual and composite models for forecasting hog prices over a fourteen-quarter period. The results of these measures might be compared with the accuracy of other forecasts made by other groups. The work reported in this note provides additional empirical evidence on composite forecasting—evidence which should be set alongside that of earlier studies (and those which may follow) to evaluate the usefulness of composite forecasting with empirical data.

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On Variances of Conditional Linear Least-Squares Search Parameter Estimates

Edmund A. Estes, Leroy L. Blakeslee, and Ron C. Mittelhammer

Among the class of models that are nonlinear in the parameters, some lend themselves to a simple estimation method requiring repeated application of linear least squares. However, there is confusion over methods for computing standard errors of such estimates.

In this paper we define a simple method for estimating parameters of certain nonlinear models and clarify the interpretation of results. This method is based on conditional linear least squares. It has been used by Just (1974a,b, 1977) to estimate a generalized adaptive-expectations supply model. We show that a method commonly used to estimate asymptotic standard errors of such parameter estimates systematically overstates precision. Factors that affect the degree of overstatement are delineated. A method of calculating correct precision measures is contrasted empirically with the incorrect procedure.

Conditional Linear Least Squares

A wide range of stochastic models used in applied research can be written in the form

$$(1) \qquad Y_t = F(X_{t1}, X_{t2}, \ldots, X_{tk}; \beta) + U_t.$$

It is assumed that the disturbances in (1) are independently and identically distributed normal random variables, and, under this assumption, nonlinear squares and maximum likelihood procedures applied to estimate β in (1) are equivalent. Note that the natural logarithm of the likelihood function associated with (1) takes the form

$$(2) \quad \ln L(\beta, \sigma^2) = -\frac{n}{2}\ln 2\pi - \frac{n}{2}\ln \sigma^2 - \frac{1}{2\sigma^2}\sum_{t=1}^{n}[Y_t - F(X_{t1}, \ldots, X_{tk}; \beta)]^2,$$

so that for any $\sigma^2 > 0$, ln L is maximized when β is chosen to minimize the residual sum of squares,

$$\sum_{t=1}^{n}[Y_t - F(X_{t1}, \ldots, X_{tk}; \beta)]^2.$$

In practice the maximum likelihood estimator $\bar{\beta}$ can be found either by solving a set of nonlinear normal equations or by using a search algorithm. In certain important applications the function F will have a form so that conditional on values of $p < m$ of the m parameters in the β vector, and on the X's, the function is linear in the remaining parameters.

Notable examples of models that have this property include the model that results from a Box-Cox power transformation of explanatory variables as

$$(3) \quad Y_t = \beta_0 + \beta_1(X_1^\lambda - 1)/\lambda + \ldots + \beta_K(X_K^\lambda - 1)/\lambda + U_t.$$

Note that (3) is linear in its parameters, given $\lambda = \beta_{k+1}$. The constant elasticity of likelihood (CES) production function, equation (4), is a second example.

$$(4) \quad Y_t = \beta_0[\beta_1 K_t^{-\beta_2} + (1 - \beta_1)L_t^{-\beta_2}]^{-\beta_3/\beta_2} e^{u_t}.$$

After logarithmic transformation it is linear in β_3 and ln β_0 if β_1 and β_2 are given. Just's (1974a,b, 1977) generalized adaptive expectations model is a third example. In its basic form, it can be written as

$$(5) \quad Y_t = \beta_0 + \beta_1 P_{t-1}^e(\beta_3) + \beta_2 V_{t-1}^e(\beta_3) + u_t,$$

where $P_{t-1}^e(\beta_3) = \beta_3 \sum_{i=0}^{\infty}(1 - \beta_3)^i P_{t-i-1}$, and

$$V_{t-1}^e(\beta_3) = \beta_3 \sum_{i=0}^{\infty}(1 - \beta_3)^i[P_{t-i-1} - P_{t-i-2}^e(\beta_3)]^2.$$

The variable Y_t above is acreage harvested in year t, P_t is price received for the crop in year t, and $P_t^e(\beta_3)$ and $V_t^e(\beta_3)$ are the mean and variance, respectively, of the subjective distribution of year $t + 1$ prices as perceived in year t. A consistent finite approximation to (5) is defined as

$$(6) \quad Y_t = \beta_0 + \beta_1[P^*_{t-1}(\beta_3) + \hat{P}^{**}_{t-1}(\beta_3)] + \beta_2[V^*_{t-1}(\beta_3) + \hat{V}^{**}_{t-1}(\beta_3)] + \epsilon_t,$$

where $P^*_{t-1}(\beta_3) = \beta_3 \sum_{i=0}^{t-t_0-1}(1 - \beta_3)^i P_{t-i-1}$,

$\hat{P}^{**}_{t-1}(\beta_3)$ is a finite consistent estimator of

$$P^{**}_{t-1}(\beta_3) = \beta_3 \sum_{i=t-t_0}^{\infty}(1 - \beta_3)^i P_{t-i-1},$$

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$$V^*_{t-1}(\beta_3) = \beta_3 \sum_{i=0}^{t-t_b-1} (1 - \beta_3)^i[P_{t-i-1} - P_{t-i-2}{}^e(\beta_3)]^2,$$

and $\hat{V}^{**}_{t-1}(\beta_3)$ is a finite consistent estimator of

$$V^{**}_{t-1}(\beta_3) = \beta_3 \sum_{i=t+t_b}^{\infty} (1 - \beta_3)^i[P_{t-i-1} - P_{t-i-2}{}^e(\beta_3)]^2.$$

Given β_3, equation (6) in linear in β_0, β_1, and β_2. Additional details are given in Just (1974a,b, 1977) and Estes.

In each of the above examples, the likelihood function can be "concentrated" on $p < m$ parameters. Let β be partitioned as $(\beta'_{m-p}\ \beta'_p)'$, and assume the entries in β have been ordered so that

$$(7)\quad F(X_{1t}, \ldots, X_{tk};\ \beta_{m-p}|\beta_p) = X(\beta_p)\beta_{m-p}.$$

Here, $X(\beta_p)$ denotes the fact that the $n \times (m - p)$ matrix of explanatory variables premultiplying the $(m - p) \times 1$ vector β_{m-p} is a function of the p parameters in the column vector β_p. Then given β_p, the logarithm of the likelihood function can be written as

$$(8)\quad \ln L(\beta_{m-p}, \sigma^2|\beta_p) = -\frac{n}{2}\ln 2\pi - \frac{n}{2}\ln \sigma^2 - \frac{1}{2\sigma^2}(Y - X(\beta_p)\beta_{m-p})'(Y - X(\beta_p)\beta_{m-p}).$$

It is clear that the maximum likelihood estimates (MLE) of β_{m-p} and σ^2, conditional on β_p, are standard linear least squares estimates, namely

$$(9)\quad \hat{\beta}_{m-p}(\beta_p) = [X(\beta_p)'X(\beta_p)]^{-1}X(\beta_p)'Y, \text{ and}$$

$$(10)\quad \hat{\sigma}^2(\beta_p) = \frac{1}{n}[Y - X(\beta_p)\hat{\beta}_{m-p}(\beta_p)]'[Y - X(\beta_p)\hat{\beta}_{m-p}(\beta_p)].$$

Substituting (9) and (10) into (8) yields the concentrated likelihood function, equation (11).

$$(11)\quad \ln L^*(\beta_p) = \max_{\beta_{m-p},\sigma^2} \ln L(\beta_{m-p}, \sigma^2|\beta_p) = -\frac{n}{2}(\ln 2\pi + 1) - \frac{n}{2}\ln \hat{\sigma}^2(\beta_p).$$

The logarithm of the concentrated likelihood function is equal to the logarithm of the original likelihood function partially maximized with respect to β_{m-p} and σ^2. Therefore $\ln L(\beta, \sigma^2)$ can be maximized by choosing the vector, β_p, which minimizes $\hat{\sigma}^2(\beta_p)$. Then the MLE for β_{m-p} is $\hat{\beta}_{m-p}(\tilde{\beta}_p)$, and the MLE for σ^2 is $\hat{\sigma}^2(\tilde{\beta}_p)$.

If p is small, say ≤ 3, and if β_p can be a priori restricted to a small subspace of R^p, then a search algorithm based on linear least squares is suggested by the results (7) through (11). Linear least squares estimates $\hat{\beta}_{m-p}(\beta_p)$ and $\hat{\sigma}^2(\beta_p)$ defined in (9) and (10) are calculated for values of β_p that have been chosen to cover the relevant values with a degree of accuracy chosen by the researcher. That value $\tilde{\beta}_p$ that yields the smallest $\hat{\sigma}^2(\tilde{\beta}_p)$ is the maximum likelihood estimator of β_p in the nonlinear model (1). The $\tilde{\beta}$ vector is composed of $\tilde{\beta}_p$, and the corresponding linear least squares estimate $\hat{\beta}_{m-p}(\tilde{\beta}_p)$ as $\tilde{\beta} = (\hat{\beta}_{m-p}(\tilde{\beta}_p)'|\tilde{\beta}'_p)'$. The values of β_p can be simply specified on a grid, or if β_p contains only a single element, the values may be chosen in a more efficient manner, say through a Fibonacci search. The linear least squares search algorithm above is recommended by Dhrymes in his work on distributed lags, and is the one used by Just (1974a,b) in his empirical work.

The asymptotic covariance matrix for the above parameter estimates may be estimated by the inverse of the information matrix, i.e., $-[E(\partial^2 \ln L/\partial\beta\partial\beta')]^{-1}$, which for models of type (1) can be consistently estimated in the following form:[1]

$$(12)\quad \text{asy}\,\hat{}\,\text{cov}\ \tilde{\beta} = \hat{\sigma}^2\left[\sum_{t=1}^{n}\frac{\partial Y_t}{\partial\beta}\left(\frac{\partial Y_t}{\partial\beta}\right)'\right]^{-1}.$$

Here, the derivatives are evaluated at the M.L. estimated point $\beta = \tilde{\beta}$. For models that are conditionally linear of the type (7), (12) further specializes to

$$(13)\quad \text{asy}\,\hat{}\,\text{cov}\ (\tilde{\beta}) = \hat{\sigma}^2(\beta_p)\left[\begin{array}{c|c} X(\tilde{\beta}_p)'X(\tilde{\beta}_p) & X(\tilde{\beta}_p)'\dfrac{\partial Y}{\partial\beta_p} \\ \hline \left(\dfrac{\partial Y}{\partial\beta_p}\right)'X(\tilde{\beta}_p) & \left(\dfrac{\partial Y}{\partial\beta_p}\right)'\dfrac{\partial Y}{\partial\beta_p}\end{array}\right]^{-1}$$

$$= \hat{\sigma}^2(\tilde{\beta}_p)\left[\begin{array}{c|c} M_1 & M_2 \\ \hline M'_2 & M_3\end{array}\right]^{-1} = \hat{\sigma}^2(\tilde{\beta}_p)\left[\begin{array}{c|c} R_1 & R_2 \\ \hline R'_2 & R_3\end{array}\right]$$

where $\partial Y/\partial\beta_p$ is evaluated at the point $\tilde{\beta}$.

Rather than use the inverse of the information matrix, it is tempting to continue the analogy with linear least squares and consider the estimated covariance matrix routinely produced by least squares procedures once $\tilde{\beta}_p$ has been determined, i.e.,

$$(14)\quad \hat{\text{cov}}\,[\hat{\beta}_{m-p}(\tilde{\beta}_p)] = \hat{\sigma}^2(\tilde{\beta}_p)[X(\tilde{\beta}_p)'X(\tilde{\beta}_p)]^{-1},$$

as a measure of dispersion for the estimates $\hat{\beta}_{m-p}(\tilde{\beta}_p)$. In recent work, Just (1977) indicates that the inverse of the information matrix provides proper estimates of asymptotic variances of estimated coefficients; but in his empirical supply analysis, (14) is used as a measure of asymptotic estimator precision and for hypothesis testing. Unfor-

[1] Results in articles by Just, Wolfowitz, and Jennrich can be used to show that given the i.i.d. normality assumption, maximum likelihood parameters estimates will be consistently and asymptotically normal if the function F is twice differentiable with respect to β in a neighborhood of the true β, and

$$\lim_{n\to\infty}\frac{1}{n}\sum_{t=1}^{n}\left[\frac{\partial Y_t}{\partial\beta}\left(\frac{\partial Y_t}{\partial\beta}\right)'\right] = Q,$$

where Q is symmetric positive definite. The particular form of the information matrix used in (12) is from Theil.

tunately, although (14) can be computed rather effortlessly, and in fact is usually standard output for most linear least squares computer routines, it is incorrect as a measure of the precision of the estimates $\hat{\beta}_{m-p}(\tilde{\beta}_p)$.

Aside from the fact that (14) provides absolutely no information about variances and covariances of entries in the $\tilde{\beta}_p$ vector nor about covariances between $\hat{\beta}_{m-p}(\tilde{\beta}_p)$ and $\tilde{\beta}_p$, what interpretation is to be given to (14)? Certainly, it is a conditional variance-covariance matrix estimate in the sense that its elements can be computed only with β_p given. But it is also conditional in a more fundamental sense. Given the asymptotic normal limiting distribution of $\sqrt{n}(\hat{\beta} - \beta)$, a conditional limiting distribution for $\sqrt{n}(\hat{\beta}_{m-p}(\tilde{\beta}_p) - \beta_{m-p})$ given $\tilde{\beta}_p = \beta_p$ can be derived. The covariance matrix (14), when multiplied by n, is a consistent estimate of the covariance matrix of this conditional limiting distribution. However, (14) multiplied by n does not provide a consistent estimate of the covariance matrix of $\sqrt{n}(\hat{\beta}_{m-p}(\tilde{\beta}_p) - \beta_{m-p})$ in the unconditional limiting distribution, which is clearly the covariance matrix of interest in defining the asymptotic covariance matrix of $\hat{\beta}_{m-p}(\tilde{\beta}_p)$.

The result (13) together with the method of partitioned inversion (Goldberger, pp. 27–28) can be used to show that the conditional asymptotic covariance matrix estimates systematically overstate the precision of the parameter estimates $\hat{\beta}_{m-p}(\tilde{\beta}_p)$. The conditional covariance matrix (14) is representable as $\hat{\sigma}^2(\tilde{\beta}_p)M_1^{-1}$, while by partitioned inversion, the submatrix of (13) corresponding to the unconditional covariance matrix of $\hat{\beta}_{m-p}(\tilde{\beta}_p)$ is

$$(15)\quad \sigma^2(\tilde{\beta}_p)R_1 = \sigma^2(\tilde{\beta}_p)[M_1 - M_2M_3^{-1}M'_2]^{-1}$$
$$= \hat{\sigma}^2(\tilde{\beta}_p)[M_1^{-1} + M_1^{-1}M_2$$
$$(M_3 - M'_2M_1^{-1}M_2)^{-1}M'_2M_1^{-1}].$$

The difference in covariance matrix estimates is then

$$(16)\quad \hat{\sigma}^2(\tilde{\beta}_p)M_1^{-1} - \hat{\sigma}^2(\tilde{\beta}_p)R_1$$
$$= \hat{\sigma}^2(\tilde{\beta}_p)M_1^{-1}M_2(M'_2M_1^{-1}M_2 - M_3)^{-1}M'_2M_1^{-1},$$

which is negative semidefinite because the inverse of the matrix in parentheses equals $-R_3$, where R_3 is a principal submatrix of a positive definite covariance matrix, and hence is itself positive definite. Therefore, PR_3P' is positive semidefinite for any P, and it follows that (16) is negative semidefinite. Since the difference in variance estimates associated with a linear combination of the parameter estimates can be written as $\hat{\sigma}^2(\tilde{\beta}_p)C'[M_1^{-1} - R_1]C$, where C defines the linear combination, and since (16) is negative semidefinite, the variance will in general be understated using the conditional covariance matrix. Furthermore, this difference is accentuated as $\hat{\sigma}^2(\tilde{\beta}_p)$ increases. It is clear from (16) that there will be no understatement of the variance of $C'\hat{\beta}_{m-p}(\tilde{\beta}_p)$ only if $M'_2M_1^{-1}C$ is the zero vector.

Finally, regarding the conditional covariance matrix, Just (1974a) has stated, "Although the standard errors reported . . . are conditional on Θ, they apply unconditionally in an asymptotic sense because Θ and ϕ are estimated consistently. Thus a discussion of the significance of results is possible although somewhat less confidence may be placed in the conclusions" (n. 15, p. 22). In a similar statement elsewhere, Just remarks, in reference to the use of conditional covariance matrices, that "t-ratios can be calculated by the usual procedure in testing and determining the significance of any coefficient estimated . . . although the significance levels indicated by the t-distribution only apply asymptotically" (Just 1974b, suppl. p. 25).

While it is true that the estimated conditional and unconditional standard errors are asymptotically equivalent in the trivial sense that they both approach zero with probability one as $n \to \infty$, this clearly does not establish the large sample validity of (14) for measuring estimator precision or for use in constructing hypothesis tests. The significance levels indicated by the t-distribution generally will be incorrect even asymptotically when using conditional variance estimates. Consider the linear hypothesis $C'\beta_{m-p} = k$, and form the t-statistic using the conditional covariance matrix (14) as

$$(17)\quad t_c = [C'\hat{\beta}_{m-p}(\tilde{\beta}_p) - k]/(\hat{\sigma}^2(\tilde{\beta}_p)C'M_1^{-1}C)^{1/2},$$

and the unconditional covariance matrix [submatrix of (13)] as

$$(18)\quad t_u = [C'\hat{\beta}_{m-p}(\tilde{\beta}_p) - k]/[\hat{\sigma}^2(\tilde{\beta}_p)C'M_1^{-1}C]^{1/2}.$$

By multiplying the numerator and denominator in (17) and (18) by $\sqrt{n}$, and letting $n \to \infty$, it is recognized that under the null hypothesis, H_0, t_u converges in distribution to a standard normal variate, and t_c converges to a random variable distributed as $N(0, \xi)$, where the variance $\xi \geq 1$ with strict equality holding in the limit iff $p\lim \frac{1}{n} C'M_1^{-1}M_2 =$ [0] (see limit theorems in Rao, p. 122). Thus, for any finite critical values $= k$ and under H_0 as $n \to \infty$,

$$(19)\quad \alpha_c = Pr[t_c \notin (-k, k)]$$
$$\geq Pr[t_u \notin (-k, k)] = \alpha_u,$$

where the probabilities α_c and α_u correspond to rejecting the null hypothesis using t_c and t_u, respectively. It is clear that if $k = t_{\alpha/2}$, where $t_{\alpha/2}$ is the critical value of the t distribution with α-level tail probability, then in the limit $\alpha_c \geq \alpha_u = \alpha$, so that a decision rule based on t_c generally accepts the alternative hypothesis too often.

In the next section we present empirical comparisons of variances and significance tests calculated in the two ways above.

Empirical Results

Just's generalized adaptive expectations model was recently applied in estimating potato acreage re-

sponse for six regions of the United States (Estes). Models of the type (6), but generalized to include other conventional regressors and expected substitute prices, were estimated using a conditional linear least squares algorithm. The specific model formulation and estimation procedure is an extension of the one proposed by Just (1977) and is discussed in detail in Estes.

Specifically, an estimation procedure was used in which the likelihood function was concentrated on the coefficient of adjustment [β_3 in model (5)], and a coarse grid search combined with a Fibonacci search was conducted over the (0, 1) interval for β_3. The interval (0, 1) is consistent with Just's (1974a) work, where he assumes that if "the state of the economic environment is positively related to the state of the immediately preceding time period, then the decision makers optimal . . . value would lie in the unit interval" (n. 5, p. 16). Given β_3, the model (6) is conditionally linear in the sense of (7). For each value of the conditioning parameter β_3 considered, a linear regression involving the remaining parameters was calculated and the residual sum of squares associated with the given β_3 value was determined. The maximum likelihood estimates were the value of $\tilde{\beta}_3$ and the values of the remaining parameter estimates, say $\hat{\beta}(\tilde{\beta}_3)$, in the associated linear regression that minimized the sum of squares to a prespecified tolerance.

Variances and covariances of coefficients, as well as asymptotic t-values, were calculated using both the conditional covariance matrix in (14), and the unconditional covariance matrix in (13). Results shown for Maine in table 1 are fairly typical of those found in the six regions in terms of overall goodness of fit.

The R^2 value was .821; all coefficients have the expected signs. As indicated by previous arguments, all t-values are smaller when calculated via the information matrix than when calculated with variances from the conditional distribution. For coefficients of mean and variance of potato price, t-values from the information matrix are less than half the values calculated with conditional variances. In addition, the information matrix approach suggests that the coefficient of adjustment [corresponding to β_3 in (5)] has been estimated fairly reliably, while the conditional variance-covariance matrix provides no information on this point.

Table 1 also provides similar information on the equation having the lowest R^2 of any of the six which were estimated, that for the Red River Valley. Here the R^2 was .545. In this case, t-values generally appeared somewhat marginal when calculated with conditional variances. When calculated via the information matrix, t-values provided little evidence of statistical significance in several cases.

Conclusions

Conditional linear least squares is an appealing estimation technique where it is applicable. However, an extension of these procedures to calculation of standard errors of coefficients often will produce seriously misleading estimates of precision. Further, the errors will all be in one direction, causing researchers to place too much confidence in their results, and rejecting single and joint null hypotheses too often. Where applicable, an alternative procedure based on the information matrix provides estimates of asymp-

Table 1. Estimated Coefficients and Alternative t-Values for Maine and Red River Valley Potato Acreage

Regressor or Coefficient Symbol	Estimated Coefficient	t-Value (Information Matrix)	t-Value (Conditional Distribution)
Maine			
Intercept	64.428	2.509	2.6834
TIME	−.318	−.919	−.9836
AP_{t-1}[a]	.760	5.057	5.0671
P_{HAY}^e	−2.323	−1.928	−2.7607
P_{POT}^e	31.658	2.069	4.6037
V_{POT}^e	−7.695	−2.115	−4.6763
$\hat{\phi}$	.397	4.567	n.a.
Red River Valley			
Intercept	33 557	.616	.670
TIME	1 809	1.435	1.450
AP_{t-1}[a]	459	1.622	1.787
P_{SB}^{e}[b]	−4 557	1.296	−2.474
P_{POT}^e	23.637	.732	1.987
V_{POT}^e	−11 1519	.788	−2.148
$\hat{\phi}$	659	1.661	n.a.

[a] Lagged planted acreage.
[b] Expected price of sugar beets.

totic standard errors which may be given a conventional interpretation.

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Simulated Behavior of Fast Food Restaurants under Alternative Cost/Volume Conditions

Lynn W. Robbins and Thomas P. Haas

The food service industry has become a major factor in total retail food sales during the past decade. Expenditures for food away from home were about 35% of all food expenditures in 1978. Between 1963 and 1978, fast food restaurant sales increased 305%, adjusted for inflation. Fast food restaurants are defined as eating establishments that utilize standard food preparation, service, equipment, management systems, and labor savings technologies in providing a limited food menu. Their share of total eating place sales more than doubled from 1963 to 1972. This share undoubtedly will show further increases as more recent data become available (Van Dress).

Changes in the socioeconomic structure of American society, such as the increasing number of working wives and single person households along with changes in income, tastes, preferences, eating habits, and a general transition to more leisure time, have contributed to expansion in food service. Growth of this magnitude creates informational needs among both industry and public sector participants. Typically, the appearance of economic, marketing, and management information about a new sector of the economy lags its growth in importance. Because of fast food's especially rapid growth, the related informational demand is large. While some research relating to fast food and other food service industries exists, information remains relatively scarce (Haas, p. 89).

A typical fast food restaurant's behavioral and operational relationships are described in detail. Some opportunities for improved marketing and operational efficiency are identified. The typical fast food restaurant is modeled and analyzed using sensitivity analyses. That is, model parameters are systematically altered to evaluate potentially viable operating policies that would be costly, time consuming, and impractical to test in reality.

In a micro sense, efficiency improvements reduce operating costs and in turn increase short-run firm profits. Industry-wide competition is enhanced as information on efficient processing and marketing reaches other firms. If marketing costs are reduced across the entire system, greater returns to producers and lower prices to consumers should result.

Research Design

Primary data were collected from a firm that franchises more than 100 fast food retail units in the southeastern United States. Selected management personnel were interviewed. Several restaurant operations were observed. Financial data were collected from eighteen restaurants stratified by sales volume from the smallest to the largest (table 1). The restaurants prepare and sell hamburgers, fish, chicken, french fried potatoes, and soft drinks, as well as offering breakfasts that include ham and eggs or sweet rolls. Meals can be eaten in the restaurant or packaged for take-out. Like most other fast food restaurants, the cooperating organizations' retail units originally offered only take-out service and later added the "eating-in" capability. Some units also added drive-up service after this study was completed.

Based on a combination of observed and recorded data and statistical results, a simulation model was constructed to mimic fast food restaurant's operating dynamics. Operational costs were tabulated and separated into fixed and variable cost components. Labor cost was determined for typical units of various sizes. Purchase dynamics were simulated using a stochastic sales generation sequence. Other operational dimensions were included in the model where quantitative relationships between dynamic components could be specified. A cumulative annual profit was simulated for the typical retail unit based on a series of daily simulation iterations. The DYNAMO Simulation Language (Pugh) was utilized.

The Simulation Model

Figure 1 provides a schematic representation of a retail fast food restaurant. Symbols are consistent with Forrester's System Dynamics methodology and variable names are defined in table 2. Circled terms are rate equation components. Rate equations are indicated by the valve symbols (fig. 1). System levels or states are enclosed in rectangles. Free-standing, underlined, parameter names indicate constant or coefficient terms. The systems cash flow follows the solid lines connecting symbols, while broken lines indicate information or influence flow between components.

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Table 1. Three Store Mean Sample Financial Statistics Ranked by Sales Volume for One Year

Sales Volume Strata	Sales Volume	Net Income	Food Cost	Paper Cost	Labor[b] Cost
	($)	(%)	(%)	(%)	(%)
1	664,385	9.7	34.9	4.6	21.9
2	497,390	6.8	35.4	4.7	24.1
3	468,902	13.6	36.3	4.5	25.4
4	397,993	8.7	34.8	5.0	25.4
5	304,356	2.5	37.6	5.2	28.1
6	265,065	−3.5[a]	36.1	4.8	30.8
Total	433,015	6.4	35.9	4.8	26.0

Strata	Insurance	Depreciation	Miscellaneous	Local Advertising and Promotion Expenses	Owner's Salary
	(%)	(%)	(%)	(%)	(%)
1	0.7	1.4	1.1	2.32	2.1
2	0.8	1.6	0.4	2.12	2.7
3	0.9	1.5	1.0	3.02	3.9
4	1.0	2.0	0.7	3.01	3.4
5	1.2	3.7	0.7	2.47	[c]
6	1.3	3.5	0.8	3.43	5.1
Total	1.0	2.3	0.8	2.71	3.1[d]

Strata	Rent	Utilities	Maintenance	Tax	Interest
	(%)	(%)	(%)	(%)	(%)
1	4.9	1.7	1.0	0.4	0.6
2	4.2	1.8	1.0	0.2	0.3
3	4.3	2.1	1.2	0.4	0.3
4	5.0	2.0	1.1	0.2	0.8
5	5.7	3.0	1.7	0.5	1.5
6	6.9	4.1	1.4	0.8	1.1
Total	5.2	2.5	1.2	0.4	0.7

[a] Values indicate net loss
[b] Excludes owner's salary; includes payroll taxes.
[c] No data available for this strata.
[d] Figure reflects only one observation.

Customer Purchase Component

Customer purchases influence marketing efficiency by generating cash flow. Customer volume is represented by dollar sales generated from a purchase rate. The simulator includes a stochastic element which creates a random customer-count response pattern within predetermined bounds. Customer response modeling is facilitated using a random number generator, NOISE, which produces uniformly distributed random numbers between −0.5 and +0.5. Customer purchase response will therefore be uniformly distributed about the constant multiplier value and constraint at the extreme by expansion or compression of the NOISE bounds. Customer response can be tailored to fit specific existing locations or proposed locations, given specific or expected traffic volume.

Average daily advertising expenditures are added directly to cost components at each time step. Actual purchases comprising cash flow dollars are created using a purchase rate equation. The purchase rate depends upon the average purchase size, which translates physical customer volume into a dollar sales volume according to the relationship:

$PURCH = ADDRAW * APS * DLINF3\ (PMA)$,

where *PURCH* is Purchase rate, *ADDRAW* is Average daily draw (customer count), *APS* is Average purchase size, *DLINF*3 is Information delay, and *PMA* is Purchase multiplier due to advertising. *DLINF*3 is an information delay that corresponds with the tendency for advertising to exhibit a lagged response.

Labor Utilization and Cost Components

Unit labor requirements are, to an extent, fixed by individual unit operational requirements. A basic core of employees is necessary regardless of volume. Personnel are constantly necessary for specific work stations. As volume increases, additional personnel are required to serve overburdened

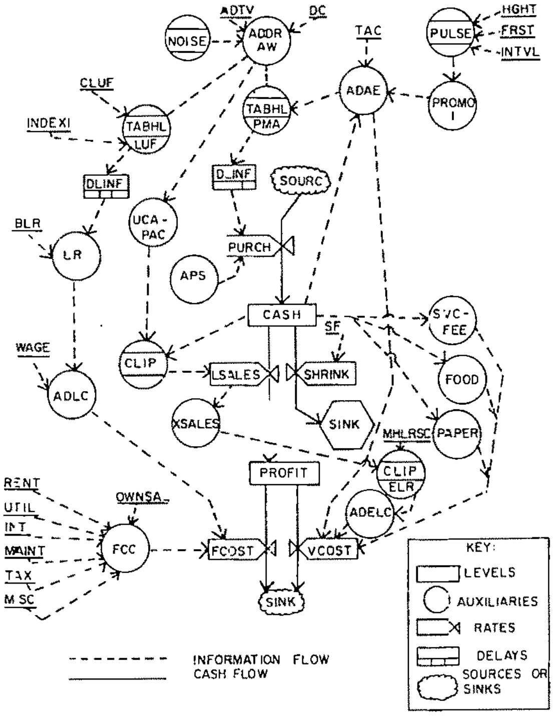

Figure 1. Fast food retail store system simulation flow chart

work stations and provide extra services, cleanup for example. While the division between basic unit requirements and variable needs is somewhat arbitrary, the model computes basic needs according to typical unit labor requirements for the lowest volume stores. The model can mimic decreased labor requirements based on improved labor utilization.

Actual labor requirements are simulated in two separate stages (both dependent upon labor productivity). Basic labor requirements and labor costs are represented by constant relationships. The second simulation stage computes additional labor requirements due to sales beyond those of the base requirements. This total labor cost component is then added to the variable cost rate equation.

Fast food restaurant operations are geared for rapid, high volume service. At some volume level, based on sales and customer count, the retail unit will encounter capacity limitations. When designed store volume is exceeded, normal work flow or service will be hampered and efficiency decreased. Additionally, lost sales may result.

Capacity restrictions are based on information provided by the cooperating firm managers. A rate equation for lost sales reflects the sales-diminishing tendency when capacity is exceeded. This cash flow drain reduces normal profits.

Cost-Profit Components

Cash flow behavior is modeled to follow the pattern existing in a cooperating organization retail store. Cost rate components represent true operational cash flow drains classified according to their fixed and variable sources. A profit-level equation is used to accumulate daily profit and loss through the course of 365 daily time steps. Individual cost sources are altered to allow for analysis of that component's impact on profit.

Rent, utilities, interest on debt, maintenance costs, taxes, and several incidental costs were classified as fixed. These costs vary little with volume changes. These fixed costs are combined with the fixed portion of labor costs necessary for basic unit operations.

Variable cost components consist of the service fee paid to central operations based on unit sales, food input costs, paper cost, average daily advertising expense, and variable labor cost above the basic

Table 2. Definition of Model Terms

ADAE:	Average daily advertising expenditure	*MHLRSD:*	Man-hour labor requirement per sales dollar
ADDRAW:	Average daily draw	*MISC:*	Miscellaneous cost components
ADELC:	Average daily extra labor cost	*OWNSAL:*	Owner's salary
ADLC:	Average daily labor cost	*PAPER:*	Paper supplies cost
ADTV:	Average daily traffic volume	*PMA:*	Purchase multiplier due to advertising
APS:	Average purchase size	*PROFIT:*	Cumulative profit level
BLR:	Basic labor requirement	*PROMOT:*	Promotional expenditure
CASH:	Cash level (daily cash intake)	*PURCH:*	Purchase rate
CLUF:	Constant labor utilization factor	*RENT:*	Rent cost
DC:	Draw constant	*SF:*	Shrink factor
ELR:	Extra labor requirement	*SVCFEE:*	Service fee
FCC:	Fixed cost components	*TAC:*	Total advertising expenditure constant
FCOST:	Fixed cost	*TAX:*	Cost of taxes
FOOD:	Food cost	*UCAPAC:*	Unit capacity
INT:	Interest cost	*UTIL:*	Utilities cost
LR:	Labor requirement	*VCC:*	Variable cost components
LSALES:	Lost sales	*VCOST:*	Variable cost
LUF:	Labor utilization factor	*WAGE:*	Wage rate
MAINT:	Maintenance cost	*XSALES:*	Extra sales

unit operational needs as defined in the labor utilization section. Additional labor costs are computed using an auxiliary which multiplies additional physical labor requirements by a wage rate component.

Actual costs are used in the simulator from the eighteen restaurants. This sample is stratified to include three units from each of six volume categories. Sample stores were drawn at random from the total cooperating organization's retail system until three sample units were attained for each volume stratum. Each volume category contains an equal number of units reflecting an almost uniform distribution of retail units from smallest to largest. Units opened within the year prior to sample selection were excluded because their cost experience is unique during the normal "startup" period. Average costs for each sales volume stratum for all cost components were calculated from actual financial statements. Table 1 lists these averages and a composite average for all stores.

Simulator Validation

The basic model was formulated to depict behavior for a cooperating organization restaurant in the sixth or lowest sales volume stratum (table 1). Results simulate a cumulative $11,518 loss for a typical store in the sixth category. Actual losses for the average stratum 6 store are $9,192. Modeling error, defined as the error in simulating the correct sales figure amounts to less than 1%. Figures for average daily advertising expense, cash flow, fixed and variable costs, and labor cost are typical for stores in this sales stratum. With actual sales exceeding simulated sales by $2,200.00 and expenses simulated accurately; simulated profit necessarily would be $2,200.00 low. Hence, the model is considered to be valid for restaurants franchised by the cooperator and will allow for adequate sensitivity analyses and evaluation.

Sensitivity Analysis Results

Firm cash flow depends in part on the average purchase per consumer. The cooperating restaurants' average purchase size ($1.50) was analyzed by increasing it over the range from $1.50 to $1.70. Simulated responses for the representative sample of purchase sizes are shown in figure 2. Results indicate that profits are sensitive to average purchase size. An increase in purchase size of 20¢ results in more than $13,000 of added returns per year. However, cooperating firm managers estimate that such an increase in average purchase size could not be generated from the estimated added revenue.

The model includes the system's behavioral decision rule that keeps advertising at some relatively constant percentage of sales. Consequently, some added advertising expense was accounted for by

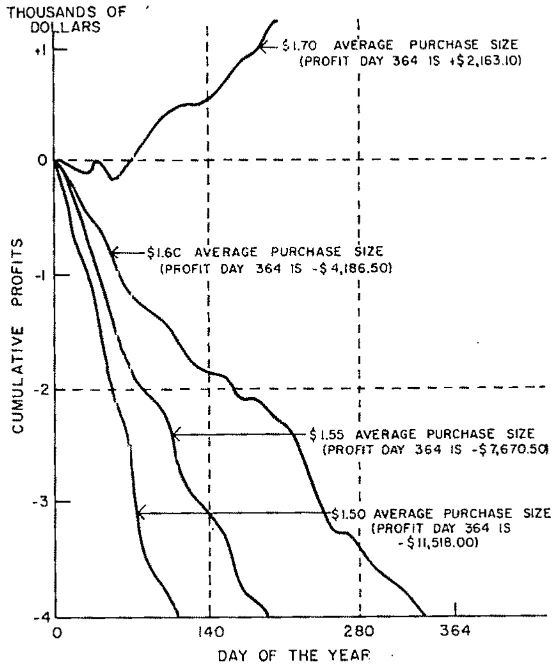

Figure 2. Simulated sensitivity of fast food retail profits to various average purchase sizes for a typical small volume store

the model as average purchase size was increased externally. The managers' assessment of the situation, however, is that a much greater promotional attempt would be needed to achieve an average purchase size of $1.70 than could be generated from the expected additional revenue. Even though profits are sensitive to average purchase size, average purchase size is not sensitive to attempts at increasing it. In essence, profits are insensitive to reasonably expected increases in purchase size.

Figure 3 depicts the results of increasing customer count. Count is at least as, if not more, sensitive than average purchase size. Managers view the likelihood of increasing count to the magnitudes analyzed in figure 3 to be much higher than similar magnitudes for purchase size. Apparently fast food restaurants are the size they are not because of individual purchase sizes but because of customer count. If a restaurant's management cannot increase customer count, continued viability must rely on cost effectiveness not revenue enhancement.

In fast food retailing, labor costs depend heavily upon the minimum wage rate. The basic model used a wage rate very near the current minimum wage rate. A lower minimum wage in the future is highly unlikely, therefore the sensitivity analysis only includes increases in wage rates for the basic store, figure 4, and for a typical high volume store, figure 5. Wage rate increases placed substantial strains on cash flow. For the low volume store, losses in-

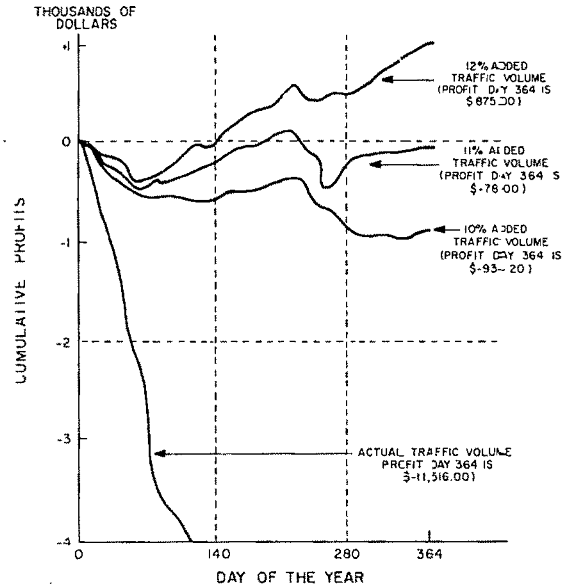

Figure 3. Simulated sensitivity of fast food retail profits to various average traffic volumes for a typical small volume store

creased more than twofold for a 30¢ increase in the average wage. Profits of high volume stores decreased by about one-third for a 30¢ wage increase.

Food and paper costs are specified as a percentage of sales. Sensitivity changes are accomplished by changing the coefficients that determine food and paper costs. Changes were tested against the basic store volume and a typical large volume store with cumulative profits amounting to $48,000. The changes for the typical large volume store are depicted in figure 6.

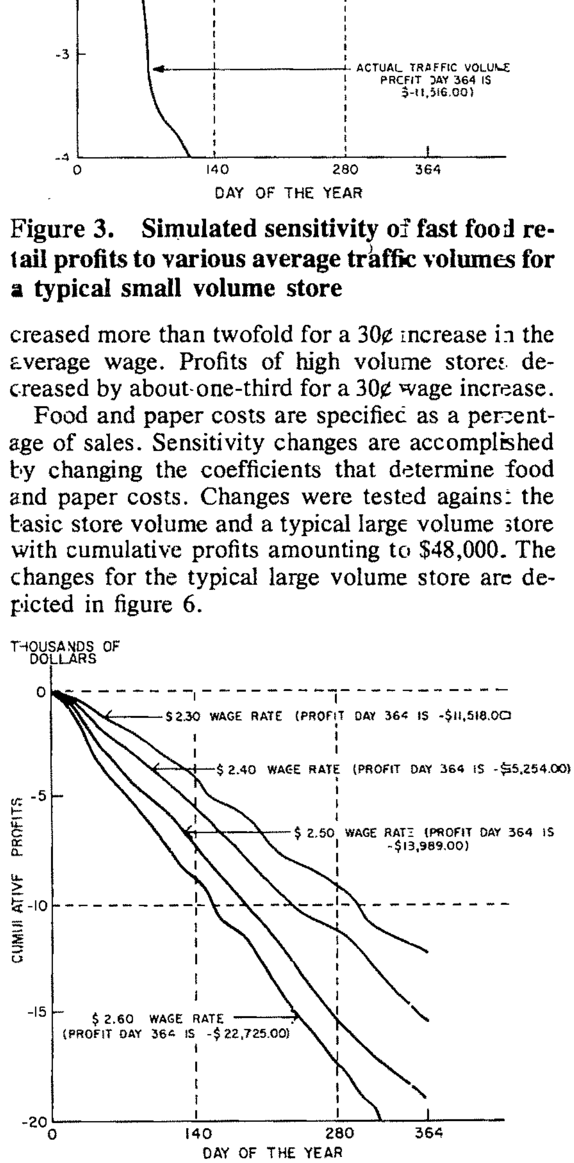

Figure 4. Simulated sensitivity of fast food retail profits to various levels of wage rates for a typical small volume store

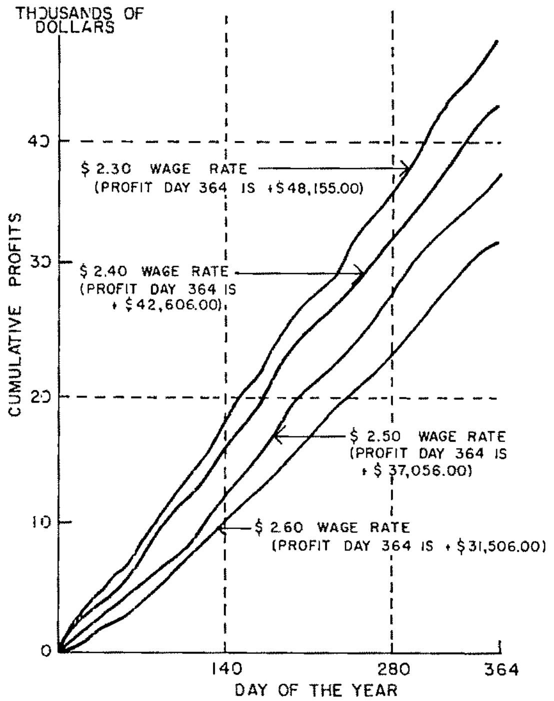

Figure 5. Simulated sensitivity of fast food retail profits to various levels of wage rates for a typical large volume store

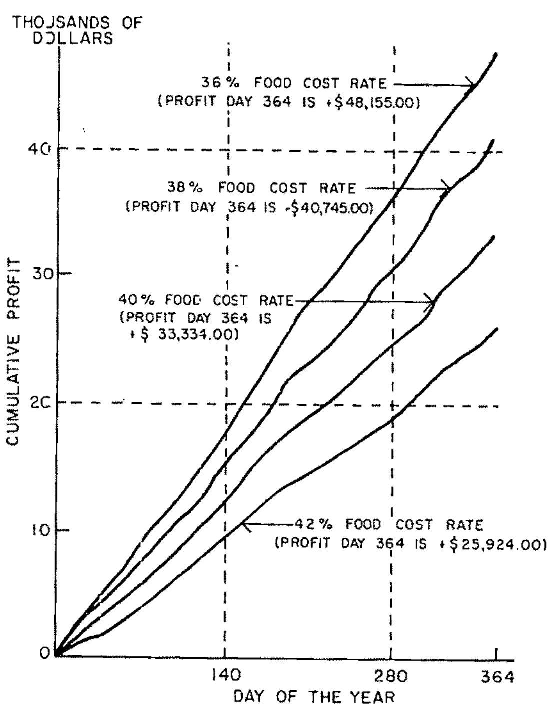

Figure 6. Simulated sensitivity of fast food retail profits to various levels of input costs for a typical large volume store

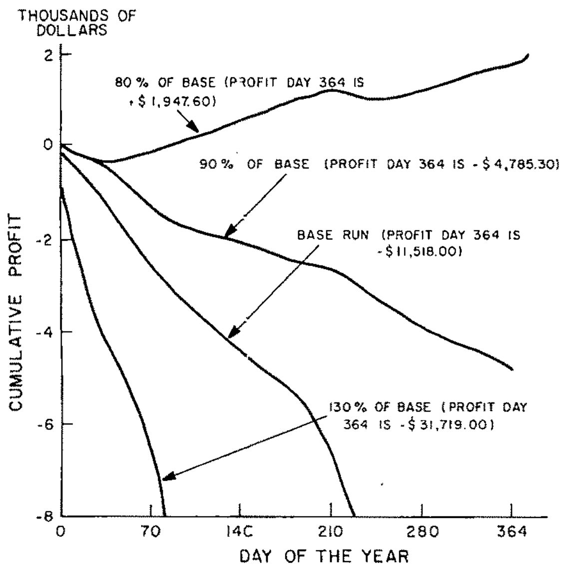

Figure 7. Simulated sensitivity of fast food retail profits to various levels of fixed costs for a typical small volume store

For the small volume unit, food costs totaling 42% of sales, as opposed to 36% in the basic model, almost treble the simulated cumulative loss. In the large volume store's case, an equal percentage food cost increase decreases profits by over 50%.

The fixed-costs variable represents a variety of fixed-cost components. Rather than test each component's sensitivity, the components were treated as a sum and indexed such that selected percentage changes in the total could be tested. In the base model, the index value is 1.0. Fixed-cost indices are tested for values ranging from 0.8, which represents a 20% decrease in all fixed-cost components, up to 1.3, representing a 30% increase in fixed costs. These changes are shown in figure 7. Basic model behavior is sensitive to fixed-cost adjustments.

Conclusions and Implications

This paper assessed particular operational criteria where marketing or operating efficiencies might be captured. Simulation analysis allowed potential operational changes to be tested against retail system behavior.

The DYNAMO-based simulation model mimicked retail operations and was accurate to within 1% of sales. The analysis revealed that many operational aspects, such as labor and food input utilization, contain sensitive parameters. Sensitive retail unit parameters are labor costs, food costs, fixed costs, average purchase size, and average traffic volume.

Four specific simulation-related conclusions and one overall conclusion came out of this research effort. First, successful attempts at increasing average purchase size provide substantially more revenue. Average traffic volume is similarly and possibly even more sensitive. The consensus among cooperating firm managers is, however, that increases in traffic count of the magnitude analyzed would be much more easily attained than those magnitudes analyzed for average purchase size. Consequently, it would appear that promotions intended to increase average purchase size, and only the average purchase size, should be discouraged. The most profit effective promotion apparently should emphasize customer count and not purchase size.

Second, profits are highly sensitive to labor costs. Increased wages decreased profits for all restaurant sizes, but smaller volume stores are more prone to pressures generated by wage increases. Current legislation and pressures from unions and other organizations aimed to increase the minimum wage rate will have a marked effect on fast food profit performance. Because labor cost constitutes a major expense category in fast food restaurants, increased efficiency can lead to significant operational economies.

Caution is required with respect to the partial equilibrium assumptions. They are that changes in wages as well as input and fixed costs affect only the simulated firm. The impact upon a firm's profits of an isolated cost increase is not the same as when it is shared by all competitors (as would necessarily be the case of a change in minimum wage). With an across-the-board cost increase, an across-the-board price increase likely would follow. If one restaurant's costs increase, they are much less likely to raise prices.

Third, it is clear that food cost is an important store performance parameter. Profits are very sensitive to food cost changes, particularly the smaller units. These smaller stores may face inefficiencies in food product buying, information discovery, or lack sufficient sales to warrant volume purchasing.

Fourth, fixed cost's sensitivity and therefore its importance is reinforced. Break-even volumes increase markedly with each increase in the fixed-cost components. As smaller volume stores become uneconomical, barriers to entry increase and competitiveness decreases.

Finally, in general it was found that without compensating unit efficiency changes through operating improvements, marketing improvements, or price increases, unit survival may be jeopardized. These pressures affect small restaurants most directly, as small units do not have the capital and informational support available to their larger counterparts. Industry structure may be adversely affected and competition curtailed if many small restaurants are pressured out of the industry. Efficiency improvements are necessary for small restaurant survival. However, large restaurant efficiency improvements result in gains to the entire industry by lowering unit costs. Under competitive conditions, these

efficiency gains will be passed to consumers through lower prices for goods and services in the food service component of consumer expenditures.

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Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportfishing

Kenneth E. McConnell and Ivar Strand

We reckon hours and minutes to be dollars and cents.
—T. C. Haliburton, *The Clockmaster*

Since the work of Cesario and Knetsch, economists have recognized that the opportunity cost of time plays an important role in determining the demand for outdoor recreation. The opportunities one has for spare time are more significant for consumption of time-intensive outdoor recreation activities than for other commodities, especially nondurables. Bishop and Heberlein illustrate "the overwhelming importance of time costs to final [recreational] values. . . . Total consumer surplus is nearly four times as large . . . [when] time costs are added at half the income rate . . . [as when] time costs were set at zero" (p. 21).

Despite the recognition, economists have neither successfully integrated the costs of time with the methods of recreational demand analysis nor reached a consensus on how it should be measured. Brown, Charbonneau, and Hay state, "Finally, the apparently crucial importance of how opportunity cost of time is handled needs further work. While we are convinced it is an appropriate concept, . . . exactly how it should be included and measured . . . remains to be determined" (p. 24). Several approaches have been taken to include it in the travel cost method. One approach (Brown and Nawas, Gum and Martin) suggests that time in transit be considered as a separate independent variable. Another approach (Bishop and Heberlein; Brown, Charbonneau, Hay; Nicols, Bowes, Dwyer; Cesario and Knetsch) measures the cost of time and adds it to other costs. Several approaches have been suggested to measure time costs. One approach is simply to choose an hourly wage, e.g., $2.00 per hour, or perhaps the minimum wage rate. A more flexible but still ad hoc approach is to use some proportion of the individual's wage rate as the opportunity cost of time (Nichols, Bowes, Dwyer). The proportion is usually taken from independent studies and used to value the travel time. This approach is better than using a constant opportunity cost of time because it allows variation across individuals. It suffers because the choice of the percentage of the wage rate is arbitrary, independent of the sampled population. Cesario has discussed the consequences of ignoring time costs and the differences in values arising from alternative measurement approaches.

In this paper, we argue that the opportunity cost of time is some proportion of the individual's market wage rate or income per hour and that this proportion can be determined from sample data. This method permits the proportion to vary from one study to another, rather than imposing either an arbitrary estimate or one from a sample different from the study's sample.[1]

A Simple Model

The recreationist presumably behaves as if to maximize utility subject to time and budget constraints by choosing trips, denoted r. The original travel cost method (Clawson) used trips per capita (z) as the dependent variable. In this paper, we have chosen to use trips per user (r). But $z = \Pi r$, where Π is the participation rate (proportion of population who participate at least once). Various studies (e.g., Deyak and Smith) have shown that decisions to participate are different from decisions about how frequently to participate. As Brown and Nawas point out, there is loss of information in aggregation. Hence it is more efficient to use r as a dependent variable. However, the method we discuss will work for z or r as the dependent variable.

Let utility be $U(x,r)$, where r is recreation trips and x is a bundle of all other goods. If we introduce a proportionate income tax rate of t, the budget constraint is

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[1] The method as described is similar in spirit to a method described in Commons. This paper, brought to our attention by a reviewer of a version of this paper, describes a method of choosing the proportion for a log-linear demand function by a search method.

$$(1) \qquad [F(w) + E](1 - t) = px + cr,$$

where w is the amount of time worked, $F(w)$ is income earned from w units of work, E is fixed income, t is the income tax rate, p is the price of the composite bundle, and c is out-of-pocket costs per recreational trip. Before-tax income is $F(w) + E$. It is the most frequent measure available from surveys. Suppose the time constraint is given by $T = ar + w$, when T is total time available and c is the amount of travel time per recreational trip.[2] The problem is to maximize

$$(2) \quad U(x,r) - \lambda\{px + cr - (1 - t)[F(T - ar) + E]\}.$$

The first-order condition for r is

$$(3) \qquad \partial U/\partial r = \lambda[c + a(1 - t)F'(w)].$$

Assuming that p does not vary across individuals, we get the demand function for recreation.

$$(4) \qquad r = f[c + a(1 - t)F'(w)].$$

Income is given by $F(w) + E$, while the marginal opportunity cost of time is $(1 - t)F'$. Define average income by $v = [F(w) + E]/w$. Sufficient conditions for the cost of time [measured by $(1 - t)F'$] to equal v are (a) The tax rate, t, is zero; (b) marginal earnings are constant: $F'(w) = F(w)/w$; and (c) nonwork income, E, is zero.

From these, it appears likely that the opportunity cost of time is less than average income. If the income figure is family income where other family members earn income and $v \equiv$ family income$/w$, the individual's opportunity cost of time will be overstated. The opportunity cost of time will be understated if an individual gets utility from work or if working today is a form of investment which provides higher income in the future.

Suppose the opportunity cost of time is some constant (k) times the average income. Then the demand function is

$$(5) \qquad r_i = f(c_i + ka_iv_i),$$

where $0 < k < 1$ is usually an arbitrarily chosen number and i is an observation index. Instead of choosing k arbitrarily, we let the sample determine k. With a linear form, we have

$$(6) \quad r_i = \beta_0 + \beta_1(c_i + ka_iv_i) + \beta_3Z_i + \epsilon_i,$$

where Z_i is a vector of exogenous variables including a wealth or income proxy and e_i is an error term with the classical specification. We can rewrite (6) as

$$(7) \quad r_i = \beta_0 + \beta_1c_i + \beta_2a_iv_i + \beta_3Z_i + e_i.$$

[2] We assume that a is travel time per trip. This approach implies that the opportunity cost of time spent on site is zero. While this is standard practice (Brown and Nawas; Shulstad and Stoevener), it is an unresolved but important issue (McConnell). We do not attempt to deal with the issue in this paper.

The estimate of k is $\hat{k} = \hat{\beta}_2/\hat{\beta}_1$, where $\hat{\beta}_i$ are the ordinary least squares (OLS) estimates of the parameters of (7). In the following section we show how this method works on a sample of sportfishermen.

An Application to Sportfishing

To test the approach suggested, we use sample data from a 1978 survey of sportfishermen in the Chesapeake Bay region. The complete specification of the equation is

$$(8) \quad r_i = \beta_0 + \beta_1c_i + \beta_2a_iv_i + \beta_3s_i + \beta_4m_i + e_i,$$

where r is the annual sportfishing trips per angler, c is per trip expenses per person, a is the round trip travel time (computed as round trip distance/45 miles per hour), v is average hourly income (annual family income/2080), s is a site variable equaling 1 for residents of Ocean City, Maryland, and 0 otherwise, and m is the length of the angler's boat.

The expected signs and relationships are $\beta_1 < \beta_2 < 0$, $\beta_3 > 0$, $\beta_4 > 0$. The first two inequalities relate to the negative effect of costs, both trip expenses and travel time, on the trips taken per year. Also, $\beta_1 < \beta_2$ implies that the opportunity cost of travel time is less than average income. The site variable (s) attempts to capture variation due to different characteristics of the sites. Since Ocean City, Maryland, was our only resort area, it was given a value of 1 and the other sites given 0. Boat length (m) represents a previous commitment to sportfishing or a wealth proxy. In either case, it should act to increase annual participation.

Fitting equation (8) on the Maryland-Virginia survey gives us

$$(9) \; r = \underset{(3.89)^*}{9.77} - \underset{(2.00)}{.0206c} - \underset{(2.50)}{.0126av} + \underset{(5.06)}{.019s} + .157m,$$

where $N = 415$, $\bar{R}^2 = .10$, $F(4,411) = 12.8$, and asterisk indicates t-statistics under the null hypothesis of no association. For this equation we have used a subset of observations from the sample.[3] The estimated coefficients agree in sign and magnitude with our prior beliefs. The equation fits reasonably well for cross-sectional observations.

[3] The subset of the sample included anglers who made twenty or fewer trips per season. To test whether the groups were different, a Chow test was used. The test statistic [$F(234,412) = 27.3$] permitted rejection at the 99% confidence level of the null hypothesis that the coefficients of the equation (9) were the same for anglers with twenty or fewer trips and anglers with more than twenty trips. We report results only for the twenty or fewer group. The hourly income variable was based on seven annual income categories ($0–$4,999; $5,000–$9,999; $10,000–$14,999; $15,000–$19,999; $20,000–$29,999; $30,000–$49,000; $50,000 and above) with the average of the category range being assigned to respondents in the category. No respondents from the lowest range were used because respondents not wishing to reveal their income often responded by indicating the lowest income class. This exclusion limits the range of v but appeared more appropriate than introducing considerable error and biased data by inclusion. For a detailed description of the survey, see Strand and Yang.

Using equation (9), we can infer that a representation angler values time at about 60% of his hourly income:

(10) $\hat{k} = \hat{\beta}_2/\hat{\beta}_1 = -.0126/-.0206 = .612.$

We expect that k will vary among regions and sites and that this value is applicable only to our sample. However, by estimating it directly from observations on individual behavior we have eliminated the need for ad hoc and arbitrary valuation of the opportunity costs of time.

Properties of $\hat{k}$

As we have observed, variations in k cause considerable variations in estimates of consumers' surplus. Our value of $\hat{k}$ is not the true value but rather the ratio of two random variables; hence, it is a random variable itself. The reliability of the estimate of consumers' surplus depends on the random properties of $\hat{k}$.

We can ascertain something of the underlying probability distribution of $\hat{k}$ from what we know of $\hat{\beta}_2$ and $\hat{\beta}_1$. Under classical assumptions, the distribution of these coefficients is jointly normal. The distribution of the ratio of two $N(0,1)$ variables is a standard form Cauchy (Johnson and Kotz, chap. 16). However, if the variables forming the ratio are jointly dependent, as are $\hat{\beta}_1$ and $\hat{\beta}_2$, then the underlying distribution is more complex (Springer, chap. 4). In both cases, however, the distributions do not have finite moments. Since confidence intervals and significance tests rely on the existence of second moments, neither of the traditional tests is applicable. We can develop some understanding of the dispersion of $\hat{k}$ by Monte Carlo studies of the ratio of jointly normal variates. This procedure offers guidance about the distribution of $\hat{k}$.

Let the joint density function of $\hat{\beta}_1$ and $\hat{\beta}_2$ be given by $f(\hat{\beta}_1,\hat{\beta}_2)$. Then

(11) $f(\hat{\beta}_1,\hat{\beta}_2) = f_1(\hat{\beta}_1)f_2(\hat{\beta}_2|\hat{\beta}_1),$

where $f_1(\hat{\beta}_1)$ is the marginal density function of $\hat{\beta}_1$, and $f_2(\hat{\beta}_2|\hat{\beta}_1)$ is the conditional density function of $\hat{\beta}_2$ given $\hat{\beta}_1$. With these conditions, it can be shown that

(12) $\hat{\beta}_1 \sim N(\beta_1,\sigma_1^2)$, and

(13) $\hat{\beta}_2|\hat{\beta}_1 \sim N[\beta_2 + \rho\sigma_2(\hat{\beta}_1 - \beta_1)\sigma_1^{-1},\sigma_2^2(1 - \rho^2)],$

where ρ is the correlation coefficient of the bivariate normal. With conditions (12) and (13) we can construct two random variables which follow (11) by calculating

(14) $\tilde{\beta}_1 = \beta_1 + \sigma_1\Theta_1,$

(15) $\tilde{\beta}_2 = \beta_2 + \sigma_2[\Theta_2(1 - \rho^2)^{\frac{1}{2}} + \Theta_1\rho]$, and

(16) $\tilde{k} = \tilde{\beta}_2/\tilde{\beta}_1,$

where Θ_i are $N(0,1)$ and independent. We performed experiments by drawing sequential pairs of unit normal random variables, assuming that the true value of β_1, β_2, σ_1, σ_2 and ρ were as estimated in equation (9). The assumed values are $-.0206$, $-.0126$, .0067, .0050, and $-.3781$, respectively.

Several experiments with sample size varying from 50 to 1,000 were conducted (table 1). Each row gives the mean value of $\tilde{k}$, the bias $(\hat{k} - \tilde{k})$, $\hat{k}$ being the ratio of estimated coefficients, the proportion of estimates greater than zero, and the proportion of estimates in the unit interval. Based on all experiments, there is an estimated probability of .016 that the estimates of $\tilde{k}$ will be less than zero. Our experiments also show that 66.7% of the sample ratios fell in the unit interval.

Although these results do not have the theoretical support of formal confidence intervals, they are informative. Despite the possibility of substantial dispersion as $\hat{\beta}_1$ approaches zero, the experiments show remarkable conformity with the distribution of estimates. Though we cannot say $\tilde{k}$ is significantly different from zero at the 98.4% level of confidence, it seems reasonable to reject the hypothesis that the ratio is less than or equal to zero.

The alternative to the Monte-Carlo approach is to assume that $\hat{k}$ is asymptotically normal with expected value $E\hat{\beta}_2/E\hat{\beta}_1$ and variance approximated by

$$(17) \quad V(\hat{k}) = (\hat{\beta}_2/\hat{\beta}_1)^2[\hat{\sigma}_1^2/\hat{\beta}_1^2 + \hat{\sigma}_2^2/\hat{\beta}_2^2 - 2\,\mathrm{cov}(\hat{\beta}_1,\hat{\beta}_2)/\hat{\beta}_1\hat{\beta}_2].$$

Using the values of their variables following equation (16), we compute $V(\hat{k}) = .142$. With these assumptions and numbers, we can construct the standard rejection region for the null hypothesis that $k = 0$. For a type 1 error of 10%, the critical region for rejection of the null hypothesis lies beyond .483. Thus, based on this approximation, we would reject the null hypothesis that $k = 0$ because the estimated value of k is .612.

The comparison of the assumption of normality with the Monte-Carlo results indicates the kinds of errors we make by assuming normality. Under the condition that $\hat{k}$ is $N(.612, .142)$, about 80% of observations so distributed will fall in the unit interval, compared with about 67% from the Monte-Carlo results. Thus, this assumption of normality with mean .61 and variance given by (17) leads to underestimating the type 1 error. This difference suggests care in the interpretation of results.

Table 1. Some Properties of $\hat{k}$ from Sampling Experiments

Sample Size	Mean Value	Bias of $\hat{k}$	Relative Frequency $\hat{k} \geq 0$	Relative Frequency $0 \leq \hat{k} \leq 1$
50	.765	$-.154$	.984	.672
500	.886	$-.247$	.983	.662
1,000	.763	$-.152$	.985	.667

Conclusions

This paper offers a method of estimating the opportunity cost of time in the demand for recreation. It can be used simultaneously with travel cost analysis, requiring only the interviewee's wage rate or income as additional data. It eliminates the need to rely on an exogenous estimate of the opportunity cost of time.

We have applied this technique to linear demand curves, and with linear functions, OLS provides direct estimates of the proportion. The general approach of letting the sample data choose the proportion is applicable to any functional form via the use of maximum likelihood techniques. An advantage of estimating k directly by maximum likelihood methods is that its asymptotic properties are well known.

The opportunity cost of time is determined by an exceedingly complex array of institutional, social, and economic relationships, and yet its value is crucial in the choice of the types and quantities of recreational experiences. Because of its complexity, one must be cautious in explaining it simply, as we have. In particular, while this method has promise, the measurements are not inconsistent with several competing hypotheses. For example, income per hour as time cost may reflect a negative income effect for sportfishing or the effect of income on the willingness to pay to avoid travel. In addition, this simple approach cannot explain why the opportunity cost of time is related to income for individuals working fixed hours.

Although this paper suggests a new direction, there are undoubtedly more advances to be made. For example, this method requires that the ratio of the opportunity cost of time to income per unit of time be constant for all sample observations. A significant improvement would be to let this ratio change as a function of leisure time or occupation.

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Producer Welfare and the Preference for Price Stability

Andrew Schmitz, Haim Shalit, and Stephen J. Turnovsky

The last few years have witnessed a phenomenal increase in price instability for final goods produced and consumed as well as inputs into production processes. As a result, an extensive literature has developed analyzing the welfare consequences of price stabilization brought about by buffer stock activities. This discussion has focused on the distribution of gains between producers and consumers as well as on the overall benefits to the economy. (For a recent survey of this literature, see Turnovsky 1978.) Much of the theoretical basis for the empirical work on the effects of stabilization policies appeared in the seminal papers by Waugh and Oi. Waugh examined the welfare effects of price instability on consumers while Oi addressed the issue of whether or not producers prefer price instability. For policy makers, the conclusion reached by Oi that producers prefer price instability to stability is somewhat disturbing because most policies—especially those in agriculture—have been aimed at creating price stability.

Recently, Tisdell (1978) extended Oi's analysis in two directions. First, he has shown that precisely the same conclusions hold with respect to instability in input prices. Moreover, under the same conditions to those assumed by Oi for the single-product case, commodity price instability (either in outputs or inputs) raises the expected profit of a multicommodity firm. Thus, the thrust of these contributions is to suggest that, insofar as producers are concerned with expected profit, they will prefer price instability—a result which greatly weakens the argument that producers should support price stabilization policies or any form of marketing arrangement where "pooled pricing" is used.

The purpose of this paper is to generalize the conditions under which producers prefer price stability. A single-product firm is first considered, and results are obtained, opposite to those of Oi, which show that a producer may prefer stability to price instability. Furthermore, this paper explores the welfare implications of price instability for a multiproduct firm, to determine whether or not a theoretical argument can be made that a firm engaged in the production of more than one type of commodity may prefer price stability for some of the commodities it produces but not for the entire set. Unlike in the Tisdell results, the findings in this paper show that a firm may prefer price stability in some products but not in others.

The firm is assumed to maximize its expected utility from profits rather than simply expected profits. The motivation for this assumption is rooted in the fact that every firm faces the possible hazard of a decline in profits that can lead to bankruptcy. Thus, instead of using the criterion of maximum expected present value of profits, over a finite or infinite planning horizon, one could provide a static approximation in the form of maximum expected utility. Then, the concept of risk aversion in the static expected utility maximization model emanates from recognition of the costs of profit variability due to price instability in the dynamic expected profit maximization model.[1] Furthermore, if the decision maker is subjectively risk-averse because of future variable profits, the utility maximization criterion is more than justified. Indeed, it is often argued in the practical stabilization literature that such producers are more concerned with the stability of their earnings than with the expected level, reflecting an attitude of risk aversion. In this case, the expected profit criterion which, in effect, assumes risk neutrality will be an inadequate measure of welfare. Accordingly, the purpose of the present paper is to reassess the benefits to producers from price stabilization in terms of a more general utility function of profits, a procedure used previously by authors in other related contexts (Sandmo, Leland). In doing so, the Oi analysis is generalized with respect to the single product and multiproduct firm.

Single-Product Case

Consider a firm that maximizes its expected utility from profits $E[U(\pi)]$. U is a Von Neumann-Morgenstern utility function assumed to be twice differentiable. It is assumed $U'(\pi) > 0$, reflecting the positive marginal utility of profit, while $U''(\pi) \gtreqless 0$, depending upon whether the firm is risk-averse or risk-preferring. (Throughout this paper, the convention of denoting partial derivatives by appropriate subscripts and letting primes denote total derivatives shall be followed.) The profit π is derived from the production process,

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[1] We are grateful to a referee for suggesting this interpretation.

(1) $y = f(\mathbf{x}_1, \ldots, \mathbf{x}_n) \quad f_i > 0, f_{ii} < 0,$

where $i = 1, \ldots, n$, f is a concave production function, $\mathbf{x} = \mathbf{x}_1, \ldots, \mathbf{x}_n$ is a vector of inputs, and y is the (single) output. The firm operates in a competitive environment and cannot influence the price of output or the price of inputs.[2] The prices of inputs are denoted by $w = (w_1, \ldots, w_n)$, while the price of output is p. These are assumed to be random variables with known probability distributions having means $E(w_i) = \bar{w}_i$, $E(p) = \bar{p}$, and a finite variance-covariance matrix. We assume, as did Oi, that the firm's decisions are always executed *ex post*, implying that, once the prices are known, the firm can adjust its inputs so as to maximize its profit. Thus, the firm more properly can be described as operating in a world of price variability rather than price uncertainty as assumed by Tisdell (1963), Sandmo, Leland, and Turnovsky (1973), among others. But the present assumption here is the one generally adopted throughout the stabilization literature. The question to be considered is whether or not the firm prefers unstable prices to prices stabilized at their arithmetic means. In this section, it will be assumed that only one price at a time is variable.

To answer the question, the firm's optimization problem must be considered, which is to

$$\max U(\pi)$$
$$\text{(2)} \qquad \text{subject to } \pi = pf(\mathbf{x}) - \sum_{i=1}^{n} w_i \mathbf{x}_i.$$

The first-order conditions for a maximum are

$$\text{(3)} \qquad pf_i(\mathbf{x}) - w_i = 0,$$

where $i = 1, \ldots, n$, where the second-order conditions are that the matrix $F = (f_{ij})$ be negative definite and are automatically satisfied by the assumption of concavity of f.

Solving (3), the optimal values of inputs and associated output are

$$\text{(4)} \qquad \begin{aligned} \mathbf{x}_i &= \phi^i(p, w_1, \ldots, w_n) \\ y &= \psi(p, w_1, \ldots, w_n), \end{aligned}$$

where $i = 1, \ldots, n$. Substituting (4) into π, the firm's utility resulting from its optimal decisions are

$$\text{(5)} \qquad \begin{aligned} U[\pi] &= U\left[p\psi(p, w_1, \ldots, w_n) - \sum_{i=1}^{n} w_i\phi^i(p, w_1, \ldots, w_n)\right] \\ &\equiv V(p, w_1, \ldots, w_n). \end{aligned}$$

The function $V(p, w) = V(p, w_1, \ldots, w_n)$, which expresses the producer's utility in terms of the prevailing output and input prices, provides the basis for analyzing the benefits from stabilization.[3] Specifically, Jensen's inequality will be used, which asserts that $EV(p, w) \gtrless V(\bar{p}, \bar{w})$, as V is convex or concave in the relevant prices. That is, the producer's welfare will be determined from the price stabilization program in terms of the convexity/concavity properties of $V(p, w)$.

Suppose that the only variable price is p, with factor prices being nonstochastic and remaining fixed at their arithmetic means. According to Jensen's inequality, the firm will lose (gain) from having p stabilized at its arithmetic mean as $\partial^2 V/\partial p^2 >$ $(<)$ 0. The second derivative of (5) with respect to p, taking into consideration that $\mathbf{x}_i$ is implicitly a function of p through (4), yields

$$\text{(6)} \qquad \frac{\partial^2 V}{\partial p^2} = U' \frac{\partial y}{\partial p} + U''y^2.$$

With some manipulation, (7) can be rewritten to give the criterion

$$\text{sgn}\left(\frac{\partial^2 V}{\partial p^2}\right) = \text{sgn}\left[\left(\frac{\mu}{1 + \mu}\right)\epsilon - r\right],$$

where $\epsilon = \frac{\partial y}{\partial p}\frac{p}{y}$, price elasticity of supply, which by virtue of (4) is positive; $r = \frac{-\pi U''}{U'}$, Arrow-Pratt measure of relative risk aversion (see Arrow and Pratt); and $\mu = (py - \sum_i w_i\mathbf{x}_i)/\sum_i w_i\mathbf{x}_i$, profit margin, as measured by profit to cost ratio. Thus, in general, whether or not producers prefer price instability depends upon three parameters: (a) the price elasticity of supply, (b) the profit margin μ, and (c) the coefficient of relative risk aversion r.

If firms are risk-neutral, the criterion (7), and also (6), depend solely on the slope of the supply curve; and as long as this is positive, it will ensure that firms prefer price instability. This, of course, was the basis of the Oi results which will continue to hold if firms are risk takers ($r < 0$). However, if firms are risk-averse, their preference for instability may cease to apply. Indeed, as the degree of relative risk aversion increases, so does the firm's preference for stability over instability. On the other hand, the firm's preference for instability increases with both the profit margin μ and the supply elasticity ϵ. For plausible parameter values, (7) could in fact be of either sign. For example, if the firm's utility function is logarithmic so that $r = 1$ and the profit margin is, say, 20%, so that $\mu = 0.2$, the preference for risk will apply if and only if the elasticity of supply $\epsilon > 6$.

[2] By treating prices as exogenous, this analysis (like the Oi analysis) is only a partial equilibrium one. A complete general equilibrium analysis would require us to endogenize prices, explaining their random movements in terms of stochastic shifts in production and preferences. This analysis does not address itself to the welfare implications for consumers.

[3] The function V is the analogue to the consumer's "indirect utility function," which has proven to be useful in analyzing similar problems for consumers; see, for example, Turnovsky, Shalit, and Schmitz.

Multiproduct Firm

Consider now a multiproduct, multi-input firm as developed within a deterministic context by Pfouts and Henderson and Quandt. The firm now produces m outputs, the prices of which $p = p_1, \ldots, p_m$ are random and uses n inputs, the prices of which $w = w_1, \ldots, w_n$ are also random. As in the single output case, all of these prices are assumed to be known prior to production decisions.

The production process of the firm producing m outputs from n inputs is characterized by the transformation function,

$$(8) \qquad H(y_1, \ldots, y_m, x_1, \ldots, x_n) = 0,$$

where H is assumed to be twice differentiable. It is assumed that H is written in such a way that the partial derivatives with respect to outputs y_j are normally positive, while those for inputs x_i are normally negative.

Thus, the firm's objective is now to max $u(\pi)$. where

$$(9) \qquad \pi = \sum_{j=1}^{m} p_j y_j - \sum_{i=1}^{n} w_i x_i,$$

subject to the production transformation process as expressed by (8). Constructing the Lagrangean expression

$$(10) \quad L \equiv U\left[\sum_{j=1}^{m} p_j y_j - \sum_{i=1}^{n} w_i x_i\right] + \lambda H(y_1, \ldots, y_m, x_1, \ldots, x_n),$$

the first-order conditions for a maximum are

$$(11a) \qquad U'(\pi)p_j + \lambda \frac{\partial H(\cdot)}{\partial y_j} = 0,$$

where $j = 1, \ldots, m$,

$$(11b) \qquad -U'(\pi)w_i + \lambda \frac{\partial H}{\partial x_i} = 0,$$

where $i = 1, \ldots, n$, together with (8) above, where λ denotes the Lagrange multiplier.

The second-order conditions require that the principal minors of the bordered Hessian matrix alternate in sign.

Solving the first-order conditions, the following solutions for the optimal inputs and outputs are obtained:

$$(12) \qquad \begin{aligned} x_i &= \phi^i(p, w) \\ y_j &= \psi^j(p, w) \end{aligned}$$

where $i = 1, \ldots, n, j = 1, \ldots, m$. Substituting (12) into π and into the firm's utility function, we derive the multiproduct analogue of (5), namely,

$$(13) \quad U[\pi] = U\left[\sum_{j=1}^{m} p_j \psi^j(p, w) - \sum_{i=1}^{n} w_i \phi^i(p, w)\right] \equiv V(p_1, \ldots, p_m, w_1, \ldots, w_n).$$

Expression (13) provides the basis for evaluating the desirability of price stabilization for a multiproduct firm.

For expositional ease, consider the important case where only one of the commodity prices is stabilized. Whether or not producers benefit from having the price p_j stabilized at its mean depends upon the convexity/concavity properties of V in terms of p_j. Following the same procedure used in the case of a single-output firm, it can be seen that

$$(14) \quad \operatorname{sgn}\left[\frac{\partial^2 V}{\partial p_j^2}\right] = \operatorname{sgn}\left[\left(\frac{\mu}{1+\mu}\right)\frac{\epsilon_j}{\alpha_j} - r\right],$$

where $\epsilon_j = \frac{\partial y_j}{\partial p_j}\frac{p_j}{y_j}$, elasticity of supply of good with respect to its own price, $\alpha_j = p_j y_j \Big/ \sum_{j=1}^{m} p_j y_j$, share of total revenue contributed by good j, and μ measures the profit margin, as defined above.

The comments made previously with respect to ϵ_j, μ, and r in connection with the single-product firm continue to apply. The interesting difference to note is that now, whether or not a firm prefers price instability with respect to a single commodity of the many it produces depends, in addition, upon the share of the total revenue contributed by this commodity. Thus, the rather strong conclusion can be drawn that a risk-averse firm may prefer instability in some of the markets for its products and not in others. However, as (14) shows, the firm is more likely to prefer price instability in those products that contribute a relatively small proportion to its total revenue.

To give the above result some real-world significance, consider the Australian and Canadian case of marketing wheat. In both countries, marketing boards are the sole sellers of wheat abroad, and the prices received by producers for a given crop year are pooled, such that each producer receives the same price regardless of when during the year the product is sold. (Interestingly, such a system also has been suggested for the United States.) However, in Canada, for crops such as flax and rapeseed, prices fluctuate on a daily basis because these are sold through the Winnipeg Commodity Exchange and not through the Board. Thus, for those crops, the timing of sales is crucial for producers. While producers generally support the Canadian Wheat Board in the marketing of wheat, recently a vote was taken among grain producers to determine if they also wanted a similar marketing system for other crops. The answer was no, and they argued that price stability through pooling was already created for the major crop, wheat, and that they wanted instability in nonmajor crops.

Conclusions

The results of this paper show that, for a multiproduct firm, stability may be preferred for some of

the products produced but not for others. Also, for a single-product firm, price stability may be preferred to price instability. These results, given the assumptions on which they are based, lend at least some support to price stabilization policies. It was shown by Massell and Samuelson that society cannot be made better off by manufacturing price instability once both consumers and producers are taken into account. The results in this paper suggest that stability may be preferable even without considering explicitly the consuming sector.

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Supply Response and the Dispersion of Price Expectations

Rulon D. Pope

One of the fundamental problems facing much economic analysis is the implication of aggregation when doing market studies. The conditions for exact aggregation under a variety of definitions and settings have been studied (Paris and Rausser, Theil). The focus of this paper is on supply response in agriculture. Several authors have studied the effects of, and tests for, differential supply response coefficients across individuals or areas when aggregating firms (e.g., Theil, p. 567). Here, these coefficients are assumed to be identical for every firm but another problem is examined when uncertainty is present.

It is well documented that farmers have diverse price expectations (e.g., Bessler). The question occurs as to the effects of such different expectations on aggregate supply response. It is found that the curvature of the supply function is a crucial component of the analysis. For example, if the supply function is strictly concave, an increase in the dispersion of expectations will reduce supply in aggregate.

The Aggregation Formulation

In order to deal with the aggregation question, consider initially N individuals with supply functions,

$$A^i = F(\bar{P}^i) \quad i = 1 \ldots N, \tag{1}$$

where A^i is acreage of the crop supplied by individual i, $\bar{P}^i$ is the expectation of price (or relative price) for firm i.[1] The total market response is

$$A = \sum_i A^i = \sum_i f(\bar{P}^i). \tag{2}$$

Equation (2) can be rewritten, letting N^s be the number of individuals with price expectation, $\bar{P}^s$:

$$A = \sum_{s=1}^{S} N^s f(\bar{P}^s). \tag{3}$$

It is convenient to rewrite (3) by defining $g(\bar{P}^s)$, which maps $\bar{P}^s$ into N^s or gives the number of individuals with expectation, $\bar{P}^s$. Implicitly, it must be assumed that $\sum_s N^s$ and (3) are finite. Let $\Omega = a, b$ denote the range that $\bar{P}^s$ can take; that is, a is the lowest and b is the highest expected price.

Assuming a large number of individuals and boundedness, equation (3) can be written

$$\bar{A} = \int_a^b g(\bar{P}) f(\bar{P})\, d\bar{P}, \tag{4}$$

where $g(\bar{P})$ is assumed for convenience to be continuously differentiable. Equation (4) can be further simplified by assuming that ${}_\Omega\int g(\bar{P})\, d\bar{P}$ is finite (and without loss of generality) and equal to one.[2] Thus, $\bar{A}$ is formed by constructing a weighted average in the discrete case, g resembles a probability density function, and $\bar{A}$ resembles an expectation for the continuous case.

The Implications of Diverse Expectations

Given the above formulation, consider the effects of diverse expectations (i.e., $g(\bar{P})$ is nondegenerate). By Jensen's inequality (Rao)

$${}_\Omega\int g(\bar{P}) f(\bar{P})\, d\bar{P} \lesseqgtr f[{}_\Omega\int \bar{P}\, g(\bar{P})] d\bar{P} \equiv f(P^*),$$

as $f'' \lesseqgtr 0$. That is, for concave f in $\bar{P}$, $\bar{A}$ is less than it would be if all individuals had price expectation, P^*, which is the average of all individuals. The converse holds for convex f and no effect is obtained for disperse expectations in the linear case. Therefore, the effects of diverse price expectations (compared to the case where all expectations are equal to the average) is to reduce (increase) total supply if the supply function is strictly concave (convex) in expected price. When the supply function is linear, diverse expectations have no impact. An attempt by government to stabilize price, and presumably expectations, at the average expected price will increase aggregate supply if the response function of each individual is concave. Such response has nothing to do with risk aversion since presumably each firm is risk neutral as only expected price enters (1)–(4). It is also apparent that any wave of optimism which redistributes the expectations upward from

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[1] Here, acreage is used as a supply variable. One also could use production when it is nonrandom. When production is random, then expected net revenue per acre may be used in place of expected price with acreage as the decision variable. Clearly, (1) as written holds other economic variables (e.g., input prices) fixed.

[2] Since ${}_\Omega\int g(\bar{P}) d\bar{P}$ is finite, one can always define prices such that the above integral is unity. Though g is written as continuous, a Lebesque-Stieltjes integral may be used for both the discrete and continuous cases. For the purposes here, little generality seems to be lost by assuming a limiting number (∞) N^s continuously on Ω.

point a will increase supply. For example, supply increases are predicted when there is a rumor that the support price for grains will be increased even though the new expected support price is lower than P^*. This is because at least some persons with low expected prices raise their expectations. This is apparent from (4), since $f' = df/d\bar{P} > 0$.

Consider next the marginal impact of a mean-preserving increase in the spread of expectations. Define $\bar{P}^0 = \gamma\bar{P} + \mu$ for all $\bar{P}$. The average price P^* will be preserved as γ increases if $P^*d\gamma + d\mu = 0$ or $d\mu/d\gamma = -P^*$. Note that

$$(4') \quad A(\bar{P}^0) = \int f(\bar{P}^0)\, g(\bar{P}^0)\, d\bar{P}^0$$
$$= \int f(\bar{P}^0) \left(\frac{1}{\gamma}\right) g(\bar{P})\, (\gamma d\bar{P}),$$

where the last equality is obtained through transformation of variables and noting that $d\bar{P}^0 = \gamma d\bar{P}$ with γ and μ fixed. Therefore, differentiating (4′) with respect to γ and evaluating at the original distribution gives the response of an average-preserving spread of the distribution of $\bar{P}$ (see Sandmo for a similar procedure in an entirely different context),

$$(5) \qquad \frac{\partial \bar{A}}{\partial \gamma} = {}_a\!\int f'(\bar{P})\, (\bar{P} - P^*)\, g(\bar{P})\, d\bar{P}.$$

It is not immediately clear from (5) whether the marginal response is negative or positive. However, integration of (5) by parts yields

$$(6) \quad \frac{\partial \bar{A}}{\partial \gamma} = \left[f'(\bar{P}) \int_a^{\bar{P}} (t - P^*)\, g(t)\, dt \right]\Bigg|_a^b$$
$$- {}_a\!\int f''(\bar{P}) \int_a^{\bar{P}} (t - P^*)\, g(t)\, dt.$$
$$= f'(b)\, {}_a\!\int (\bar{P} - P^*)\, g(\bar{P}) d\bar{P} - f'(a) \cdot 0$$
$$- {}_a\!\int f''(\bar{P}) \int_a^{\bar{P}} \bar{P}(t - P^*)\, g(t)\, dt$$
$$= - {}_a\!\int f''(\bar{P}) \left[\int_a^{\bar{P}} (t - P^*)\, g(t)\, dt \right] d\bar{P},$$

where the third equality follows by noting that ${}_a\!\int (\bar{P} - P^*)\, g(\bar{P})\, d\bar{P} = 0$. The square bracketed term in this equation is nonpositive since $P^* = {}_a\!\int t\, g(t)\, dt$. Thus, sign $f''(\bar{P})$ and concavity in $\bar{P}$ implies that a marginal increase in the dispersion of price expectations reduces supply. It is also clear from (6) that larger values of $[f''(\bar{P})]$ imply larger values of $\partial\bar{A}/\partial\gamma$. Thus under concavity, when supply is sharply curved, a larger reduction in supply will occur as individuals' beliefs become more disperse compared to the case where supply is nearly linear.

These analytical results suggest a series of testable hypotheses about the supply effects of the distribution of expectations and its changes over time. However, data on the distribution of expectations and its changes are rare or nonexistent in agriculture. Yet there is little hope of substantiating this particular hypothesis without more data.

If one considers a Bayesian process where prior beliefs are revised by sampling current year's price, then identical priors lead to identical posterior-expected prices (see Theil, p. 666). Thus, the dispersion in expected prices is zero. However, if events turn out such that each person has the same prior mean but different precisions of his expectations, then the posterior-expected prices are not identical. Presumably, the posterior distribution of the current year is modified by other information (e.g., policy announcements) to form the prior for next year's expected price.

An important lesson is suggested by this example. We expect information to be gathered only when we are unsure of the probability distribution. For instance, no experimentation would be undertaken to learn the probabilities associated with the toss of fair coin. Thus, where there is an active information market, this is likely evidence of disperse expectations and differential information. Such information may be especially sought after during periods of increased volatility. The essential point is that we know little about how priors are formed and the nature of the information processed. Thus we can only speculate on the nature of the distribution of expectations across individuals and how it changes. Yet, a priori it does seem likely that an increase in perceived variability in the market leads to greater dispersion in expectations across individuals, and, for a single individual, less precision in his estimates of expected price. (Perhaps one would not expect increased dispersion if futures' prices were used to form producer expectations. However, the Bessler study suggests substantial dispersion of expectations). Thus, one may observe supply response due to increased variability of prices but with all firms risk neutral. The practical implication here is that increases in information or extension work aimed at better informing the "optimists" and "pessimists" (the extremes) may increase (or decrease) supply. Such information need only be directed at the first subjective moment of price, its expectation. That is, if an increased variance of P were to reduce acreage, one need not interpret this as evidence of risk aversion. As shown earlier, if increased variability of price (measured in aggregate, e.g., a distributed lag on historical prices) implies greater dispersion of expected price across individuals, then aggregate supply may respond to the variability of historical prices—even given risk neutrality. This effect occurs because some individuals' expected prices are altered as the environment gets more risky. Yet, each firm in our model is risk neutral and does not respond to subjective variance.

Suppose expected price is perceived by two individuals to be \$3.50 per bushel. Each supply curve is

supply is $\bar{A} = 2 \times 75 \times (3.50)^{.6} = 318$. Consider now the case where the first farmer expects price to be \$4; the other expects \$3. In this case, total supply is approximately 317. Thus, an increase in dispersion in price expectations leads to a reduction in supply. This occurs because when the function is concave, then the decrease in supply by the second farmer outweighs that increase in supply by the first farmer.

The above example can be graphed simply by putting the expected prices in frequency form. This will halve aggregate supply or normalize it on the number of economic agents used in calculating frequencies. We obtain in the first case a frequency of 1 for $\bar{P}$ = \$3.50. In figure 1, aggregate supply is given at $\bar{A}'$(159). In the second case, the frequencies are ½ for \$4 and \$3, respectively. All possible frequencies of \$4 and \$3 and aggregate supply are given by the line aDB. For frequencies of ½, supply is $\bar{A}''$ (158.5) and the distance DC ($\bar{A}' - \bar{A}''$) measures the reduction in aggregate supply due to disperse expectations.

Finally, since the results here depend a great deal on the curvature of the supply function, a few comments are in order on that function's shape. The linear function is not necessarily consistent with theory (Pope). Yet, it may reasonably be considered as a first-order approximation of any arbitrary function. If the supply curve were linear, an increase in the dispersion of expected price (preserving the average) would not change supply. Yet, the theory of the competitive firm gives us only that $\partial A^i/\partial \bar{P}^i \geq 0$.

It is instructive to examine in a very simple case the properties of the supply function when it is not linear. Since $\bar{P} = MC\ (A)$ represents the inverse supply function where MC is marginal cost, the supply function is given by $A = MC^{-1}(\bar{P})$. Since $\partial^2 A/\partial \bar{P}^2 = -MC''(A)/[MC'(A)]^3$, it follows that if marginal cost is convex ($C''' > 0$), then the supply function is concave.

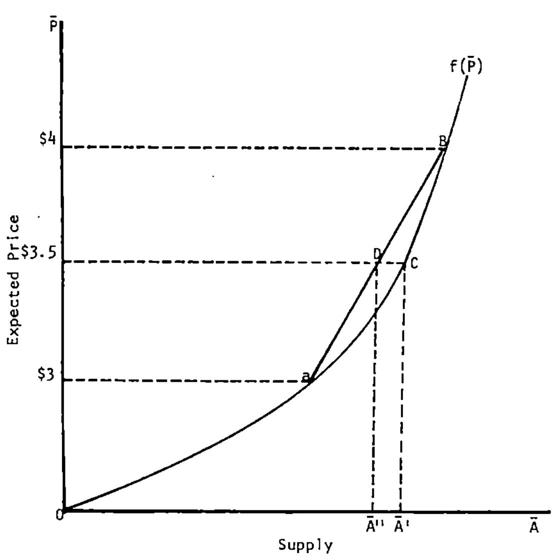

Figure 1. Supply effects of diverse expectations

The marginal cost function is concave when the cost of an additional unit of output increases at an increasing rate. In general, this will occur when production capacity is strictly limited, when strongly diminishing returns are present in the underlying production function, or if one or more important inputs are inelastic in their supply.

Concluding Comments

It is clear that the above reasoning can be applied to a wide variety of problems in economics. For example, permanent income in consumption theory may be uncertain. Its dispersion can affect total consumption. In any case, the purpose of this paper is to explore the implications of aggregation when something in the environment is random. This randomness leads to diverse *ex ante* anticipations. Though the risk-neutral case is explored here, similar results follow for a risk-averse firm. It is particularly interesting, however, that risk neutrality under price uncertainty yields results similar to the supply response analysis under risk (e.g., Just) where variability is negatively correlated with total acreage of a crop (*ceteris paribus*). An interesting area of future research may involve the relationship between the level and dispersion of subjective expectations and socioeconomic variables (e.g., Binswanger). Such information, coupled with some knowledge of the curvature of the supply functions, may help us interpret aggregate supply phenomena in new and useful ways.

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On Implicit Forms of Multiproduct-Multifactor Production Functions

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A quest for generality in economic analysis appears to underlie the long tradition of the use of implicit functions. However, insufficient attention is given to weaknesses and limitations of implicit functions as they are traditionally used (e.g., Cohen and Cyert, Hadar, Henderson and Quandt, Malinvaud, Naylor, Naylor and Vernon, and Samuelson, among others). Careless use of implicit functions can result in faulty analysis. In particular, clarification of these limitations is needed, especially as they pertain to the study of multiproduct-multifactor (MP-MF) production processes.[1]

This paper is a rigorous examination of certain issues regarding implicit functions and MP-MF production processes. Because any relation that explicitly determines one argument as a function of the remaining arguments can be written in implicit function form, our results also apply to explicit function representations of MP-MF production. The functions examined here are continuously differentiable and can be used as production feasibility constraints in a Lagrangian or Kuhn-Tucker analysis of the MP-MF firm.

The theory of MP-MF production is relevant in the conceptualization of resource allocation problems throughout agriculture. For example, few important real-world analyses of agricultural production or marketing operations are single product in nature. In fact, in his extensive literature review on production efficiency in agricultural processing and marketing, French states "multiple outputs are effectively the rule rather than the exception." Similarly, MP-MF theory is prominent in the study of environmental and natural resource problems involving technological externalities. Despite the importance of the theory, it appears that work to date is a collection of special cases of a potentially more general theory. It is our hope that this paper will stimulate a reexamination of MP-MF production theory.

Single-Equation, Implicit Function Representations

Let $F(Z_1, \ldots, Z_p, X_1, \ldots, X_n)$ be a continuous real-valued function defined on the nonnegative orthant in $n + p$ space. Equation (1) is assumed to represent a MP-MF production process relating inputs $(X_1, \ldots, X_n)$ and outputs $(Z_1, \ldots Z_p)$, e.g., see Hadar, Henderson and Quandt, Hicks, Naylor, Naylor and Vernon, Samuelson. Here,

$$(1) \qquad F(Z_1, \ldots, Z_p, X_1, \ldots, X_n) = 0,$$

and will be referred to as the single-equation, implicit function representation (SEIFR) of MP-MF production.

It is generally assumed either explicitly or implicitly that, in a certain domain, F is continuously differentiable with respect to all of its arguments and that the first-order partial derivatives of F are nonzero. In this relevant domain, the partial derivatives $\partial F/\partial Z_i$, $i = 1, \ldots, p$ are assumed to be all of one sign, while the partial derivatives $\partial F/\partial X_j, j = 1, \ldots, n$ are assumed to be all of the opposite sign. Some far-reaching implications of these apparently innocuous assumptions are identified in the following theorem and the discussion that follows.

THEOREM 1. *Under the assumption that all first-order partial derivatives of* F *exist and are nonzero in a certain domain, a production process represented by*

$$(2) \qquad F(W_1, \ldots, W_m) = 0$$

is such that every differentiable local solution for every W_j depends actively on all other W_i, $i \neq j$, in the sense that all $\partial W_j/\partial W_i \neq 0$.

Proof. Let the function F have the assumed properties in a certain domain. Then, if $W_j = \psi_j(W_1, \ldots, W_{j-1}, W_{j+1}, \ldots, W_m)$ is a differentiable local solution for W_j on some neighborhood N, $F[W_1, \ldots, W_{j-1}, \psi_j(W_1, \ldots, W_{j-1}, W_{j+1}, \ldots, W_m), W_{j+1}, \ldots, W_m] = 0$ throughout N. Then, for $i \neq j$, $(\partial F/\partial W_j)(\partial\psi_j/\partial W_i) + \partial F/\partial W_i = 0$ on this neighborhood. Hence, $\partial W_j/\partial W_i = \partial\psi_j/\partial W_i \neq 0$. That is, every local solution of (2) for W_j depends actively on all other W's. The result holds for all j. Q.E.D.

Applying Theorem 1 to equation (1) results in marginal products $\partial Z_i/\partial X_j$, marginal rates of product transformation (MRPT) $\partial Z_i/\partial Z_j$, and marginal rates of technical substitution (MRTS), $\partial X_i/\partial X_j$, all being nonzero. Furthermore, under the assumption

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[1] Dano gives one of the most complete presentations of multiproduct-multifactor production. While he recognizes several limitations embodied in implicit functions, his treatment is not as clear and rigorous as deserved.

of continuous differentiability, the implicit function theorem guarantees the existence of these derivatives in the relevant domain, and the simple implicit function rule of the calculus can be used everywhere in that domain to find derivatives between the arguments of F as

$$(3)\quad \begin{aligned} \partial Z_i/\partial X_j &= -(\partial F/\partial X_j)/(\partial F/\partial Z_i), \\ \partial Z_i/\partial Z_j &= -(\partial F/\partial Z_j)/(\partial F/\partial Z_i), \text{ and} \\ \partial X_i/\partial X_j &= -(\partial F/\partial X_j)/(\partial F/\partial X_i). \end{aligned}$$

The assumption that $\partial F/\partial Z_i$ and $\partial F/\partial X_j$ are of opposite sign for any $i = 1, \ldots, p$ and $j = 1, \ldots, n$ assures [from (3)] that marginal products are positive, $\partial Z_i/\partial X_j > 0$, MRPTs are negative, $\partial Z_i/\partial Z_j < 0$, and MRTSs are negative, $\partial X_i/\partial X_j < 0$, in the relevant domain.

Given the stated assumptions, the SEIFR (1) portrays a very restrictive model of MP-MF production—one in which each output depends actively on all inputs and other outputs listed as arguments of F. Despite this limitation, authors have referred to representations of the type (1) either explicitly (e.g., Malinvaud, p. 46) or implicitly (e.g., Henderson and Quandt, p. 95) as the general representation of MP-MF production. In fact, the illusion of generality created by (1) has resulted in erroneous analysis in the literature. For example, consider the MP-MF production function presented by Naylor, and again by Naylor and Vernon:

$$(4)\quad F(Z_1, \ldots, Z_p, X_{11}, \ldots, X_{nl}, \ldots, X_{np}) = 0,$$

where X_{ik} is purported to represent the quantity of the ith input used in the production of the kth output, and F is assumed to be continuously differentiable with nonzero derivatives in the relevant domain. The explicit distribution of inputs among the various outputs implied by double subscripting in (4) is meaningless; from Theorem 1, a production process characterized by such an explicit distribution of inputs cannot be represented by (4) under the stated assumptions. Each of the p output levels could be directly affected by changing any of the input levels, regardless of their subscripting. Attempts by Naylor, and Naylor and Vernon to force explicit distribution of inputs to outputs by use of a SEIFR, such as (4), were futile under the stated assumptions.

Samuelson (p. 236) suggested that any number of independent constraints on input-output combination could be represented by a single equation $F = 0$. For example, a production relation (1) with the specific form,

$$(5)\quad F(Z_1, Z_2, X_{11}, X_{21}, X_{12}, X_{22}) = [g_1(Z_1, X_{11}, X_{21})]^2 + [g_2(Z_2, X_{12}, X_{22})]^2 = 0,$$

is equivalent to the pair

$$(6)\quad \begin{aligned} g_1(Z_1, X_{11}, X_{21}) &= 0, \\ g_2(Z_2, X_{12}, X_{22}) &= 0, \end{aligned}$$

where Z_1 and Z_2 clearly depend (implicitly) only on (X_{11}, X_{21}) and (X_{12}, X_{22}), respectively. Giving little attention to this issue, Samuelson dismissed such a representation as "trivial." Trivial or not, there is a compelling practical reason for not using this representation—it would require relaxing the traditional assumption of nonzero partial derivatives. In fact, any such representation with F continuously differentiable necessarily results in grad **F**, the gradient vector of F, vanishing wherever $F = 0$. Subsequent use of Lagrangian and Kuhn-Tucker methods is invalidated and the implicit function rule is rendered inoperable. The vanishing of grad **F** is proved as a special case of theorem 2.

THEOREM 2. *Suppose $F_1(W_1, \ldots, W_m), \ldots, F_q(W_1, \ldots, W_m)$ are all continuously differentiable on a domain D, and that there exist $p > q$ independent*[2] *differentiable functions $g_1(W_1, \ldots, W_m), \ldots, g_p(W_1, \ldots, W_m)$ on D such that $g_1 = \ldots = g_p = 0$ at every point of D where $F_1 = \ldots = F_q = 0$. Then, if J is the Jacobian matrix $\partial(F_1, \ldots, F_q)/\partial(W_1, \ldots, W_m)$, we have rank $J < q$ wherever $F_1 = \ldots = F_q = 0$.*

Proof. Suppose that $F_1, \ldots, F_q, g_1, \ldots, g_p$ satisfy the hypotheses. Then $q < m$, for in the contrary case we would have (at every point of D) the $p > q \geq m$ linearly independent m-vectors grad $g_1, \ldots,$ *grad* $\mathbf{g}_p$, which is impossible.

Now let $\bar{W} = (\bar{W}_1, \ldots, \bar{W}_m)$ be a point of D at which $F_1 = \ldots = F_q = 0$, and suppose rank $J = q$ (clearly rank $J \leq q$) at $\bar{W}$. For concreteness, suppose that the left-most $q \times q$ submatrix of J, $\partial(F_1, \ldots, F_q)/\partial(W_1, \ldots, W_q)$ is nonsingular at $\bar{W}$. Then, by the implicit function theorem, there exists a differentiable local solution (near $\bar{W}$) of $F_1 = \ldots = F_q = 0$ for $W_1, \ldots, W_q$:

$$(7)\quad \begin{aligned} W_1 &= f_1(W_{q+1}, \ldots, W_m), \\ &\;\;\vdots \\ W_q &= f_q(W_{q+1}, \ldots, W_m). \end{aligned}$$

Then, for all $i = 1, \ldots, p$,

$$(8)\quad \mathbf{g}_i[f_1(W_{q+1}, \ldots, W_m), \ldots, f_q(W_{q+1}, \ldots, W_m), W_{q+1}, \ldots, W_m] = 0,$$

and therefore, for $k = q + 1, \ldots, m$,

$$(9)\quad \sum_{j=1}^{q} \frac{\partial \mathbf{g}_i}{\partial W_j} \frac{\partial f_j}{\partial W_k} + \frac{\partial \mathbf{g}_i}{\partial W_k} = 0.$$

In other words, each of the vectors grad $\mathbf{g}_i$ (at $\bar{W}$) satisfies the equation (grad $\mathbf{g}_i)M = 0$, where M is the $m \times (m - q)$ matrix

[2] In the usual sense that the row gradient vectors grad $\mathbf{g}_1, \ldots,$ grad $\mathbf{g}_p$ are linearly independent at every point of D.

$$\begin{bmatrix} \partial f_1/\partial W_{q+1} & \dots & \partial f_1/\partial W_m \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \partial f_q/\partial W_{q+1} & \dots & \partial f_q/\partial W_m \\ \hdashline 1 & 0 \dots & 0 \\ 0 & 1 \dots & 0 \\ 0 & 0 \dots & 1 \end{bmatrix},$$

whose rank is $m - q$. Thus the solution space of $(\text{grad } \mathbf{g}_i)M = 0$ has dimension q, so the $p > q$ vectors grad $g_1, \dots,$ grad g_p must be linearly dependent, in contradiction to the assumption. Therefore, $\partial(F_1, \dots, F_q)/\partial(W_1, \dots, W_q)$ is singular. The choice of the $q \times q$ submatrix of J was arbitrary, so rank $J < q$—that is, J has less than full row rank. Q.E.D.

If one equation is used to represent the production process as in (1) or (4) and to force more than one independent functional constraint on the arguments of F, as in (5), then Theorem 2, with $q = 1$ and $p > q$, implies that the Jacobian (which in this case is the row vector grad $\mathbf{F}$) will have zero rank Thus grad $\mathbf{F}$ must be the zero vector. Unfortunately, Lagrangian and Kuhn-Tucker conditions are no longer necessary conditions for optimality in a problem having $F = 0$ as a constraint since, in the case at hand, the Jacobian matrix of the constraint functions will have the zero row grad $\mathbf{F}$ as one of its rows, and thus will be less than full row rank.[3] In addition, with grad $\mathbf{F} = [0]$, the useful implicit function rule [e.g., see Henderson and Quandt, Chiang, and recall (3)] cannot be used to define derivatives anywhere.

Unless it were completely unavoidable, it would seem that most economists would prefer not to invalidate the familiar Lagrangian or Kuhn-Tucker methods, and to maintain the availability of other useful tools of the calculus in the general functional representation of MP-MF production. Fortunately, such a representation of MP-MF production is available, having the ability to depict processes other than those for which each output is affected directly by the levels of all inputs and other outputs. This generalization is examined in the next section.

Vector-Equation, Implicit Function Representation

In this section we present the canonical form of the vector-equation, implicit function representation (VEIFR) of MP-MF production. More than one independent functional constraint on input-output combinations can be accommodated without invalidating Lagrangian or Kuhn-Tucker methods. However, derivatives between problem arguments will generally no longer be derivable using the simple implicit function rule method, but will require a more general method of derivation. In addition, the interpretation of these derivatives generally differs from traditional interpretations.

The VEIFR of MP-MF production is

$$(10) \quad \begin{aligned} &F_1(Z_1, \dots, Z_p, X_1, \dots, X_n) = 0, \\ &\qquad \cdot \\ &\qquad \cdot \\ &\qquad \cdot \\ &F_r(Z_1, \dots, Z_p, X_1, \dots, X_n) = 0, \\ &\qquad r \leq n + p. \end{aligned}$$

Each F_i is assumed continuously differentiable, and some $(r \times r)$ submatrix of the $r \times (n + p)$ Jacobian matrix of (10) is nonsingular in the relevant domain.

The VEIFR can be written more compactly in vector function form as

$$(11) \quad \underset{(r \times l)}{F(Z, X)} = \underset{(r \times l)}{[0]} \text{ s.t. } r \leq n + p \text{ and } \rho(J) = r,$$

where

$$J = [\partial F/\partial Z \ \vdots \ \partial F/\partial X],$$

$$\partial F/\partial Z = \begin{bmatrix} \partial F_1/\partial Z_1 & \dots & \partial F_1/\partial Z_p \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \partial F_r/\partial Z_1 & \dots & \partial F_r/\partial Z_p \end{bmatrix},$$

$$\partial F/\partial X = \begin{bmatrix} \partial F_1/\partial X_1 & \dots & \partial F_1/\partial X_n \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \partial F_r/\partial X_1 & \dots & \partial F_r/\partial X_n \end{bmatrix},$$

$Z = (Z_1, \dots, Z_p)$, $X = (X_1, \dots, X_n)$, and $\rho(J) = r$ states that the rank of J is r in the relevant domain.

Up to $r = n + p$, independent constraint equations can be accommodated in this mathematical representation of production. The full complement of input and output variables need not appear as arguments of all r-functions in the representation; each is listed as an argument of all functions for convenience only. An argument may be effectively deleted from a function when the derivative of the function with respect to the argument is assumed to be identically zero. Since $F(Z, X)$ is assumed continuously differentiable, and because $\rho(J) = r$, there is nothing inherent in the VEIFR that would invalidate the Lagrangian or Kuhn-Tucker conditions in an economic optimization problem using the VEIFR of MP-MF production as a feasibility constraint.

When $r > 1$, interpretations of derivatives between arguments of F and methods for deriving them can be troublesome. For simplicity and con-

[3] Full row rank of the Jacobian matrix of the constraint functions is a requirement for Langrangian and Kuhn-Tucker conditions to be necessary for characterizing optimal solutions. This is a version of the constraint qualification often discussed in conjunction with Kuhn-Tucker methods. In particular, in problems having both equality and inequality constraints, the Jacobian matrix of interest consists of the gradient vectors of the functions involved equality constraints, and the gradient vectors of the functions involved in binding inequality constraints. For further details, see Bazaraa and Shetty, chapter 5.

sistency with the notation of the theorems rewrite (1) as

$$F_1(W_1, \ldots, W_m) = 0$$
$$(12) \qquad \vdots \qquad\qquad \vdots\ ,$$
$$F_r(W_1, \ldots, W_m) = 0$$

($r \le m$). Suppose we wish to assign a meaning to $\partial W_i/\partial W_j$ at a point $\bar{W} = (\bar{W}_1, \ldots, \bar{W}_m)$ where the equations (12) are satisfied. This ordinarily would be taken to mean the rate of change in W_i when W_j changes and all the other entries in W are held fixed. However, it may be impossible to hold $m - 2$ of the arguments in (12) fixed without forcing the other two to remain fixed also—or violating (12). For example, let $W_1 - W_2 = 0$, $W_2 - W_3 = 0$. As soon as the value of any one argument is fixed, so are those of the others.

A more subtle attack on the problem uses the implicit function theorem. Again, assume that the functions $F_k (k = 1, \ldots, r)$ are continuously differentiable and that their Jacobian matrix at $\bar{W}$ has rank r. Suppose there exist $r - 1$ indices $k_2, \ldots, k_r$ between 1 and m inclusive, not including i and j (this implies $r < m$), such that the $r \times r$ submatrix M of the Jacobian matrix corresponding to the variables $W_i, W_{k_2}, \ldots, W_{k_r}$ is nonsingular at $\bar{W}$. To make the rest of the discussion more specific, but not less general, we shall assume $i = 1, k_2 = 2, \ldots, k_r = r$, and $j = m$. Then, on some neighborhood of $(\bar{W}_{r+1}, \ldots, \bar{W}_m)$ in $(m - r)$-space, the equations (12) may be solved uniquely for $W_1, \ldots, W_r$:

$$W_1 = \Theta_1(W_{r+1}, \ldots, W_m),$$
$$(13) \qquad \vdots \qquad \vdots$$
$$W_r = \Theta_r(W_{r+1}, \ldots, W_m),$$

where the continuously differentiable functions Θ_k satisfy $\Theta_k(\bar{W}_{r+1}, \ldots, \bar{W}_m) = \bar{W}_k (k = 1, \ldots, r)$. In particular, $\partial W_i/\partial W_j$ (equal to $\partial W_1/\partial W_m$) may now be unambiguously interpreted as the value of $\partial\Theta_1/\partial W_m$ at $(\bar{W}_{r+1}, \ldots, \bar{W}_m)$. This derivative also may be found directly by differentiating implicitly in (12) with respect to W_m, treating $W_{r+1}, \ldots, W_m$ as the independent variables, and solving the resulting linear equations, perhaps by Cramer's rule. The assumption that the submatrix M is nonsingular guarantees that there is a unique solution. This procedure might naturally be described as the generalized implicit function rule.

The point, however, is that the interpretation of $\partial W_i/\partial W_j$ obtained in this way is not as unambiguous as it may at first appear, because it depends, in general, on the choice of the indices $k_2, \ldots, k_r$. That this dependence can be genuine is illustrated by the following simple example: Let $r = 2$, $m = 4$,

$$F_1(W) = W_1 + W_2 - W_3 - W_4,$$
$$F_2(W) = W_1 + 5W_2 - 2W_3 - 3W_4,$$

and $\bar{W} = (1, 1, 1, 1)$. All 2×2 submatrices of the Jacobian matrix are nonsingular. Then depending upon whether k_2 is chosen to be 2 or 3, the generalized implicit function rule yields ½ or -1 as the value of $\partial W_1/\partial W_4$ at $\bar{W}$.

Under the not untypical circumstances just exemplified, one might use a symbol such as $\partial W_i/\partial W_j|(W_{k_2}, \ldots, W_{k_r})$ to distinguish the different possible interpretations of the partial derivative. Each depends on the choice of variables that are treated as dependent [implicitly defined by (12)] along with W_i. These derivatives might reasonably be called conditional partial derivatives.

In the case $r = 1$, the ordinary implicit function rule yields at most one value of $\partial W_i/\partial W_j$, so the problem we have just discussed does not arise. In general, as many as $(m - 2)!/[(r - 1)!(m - r - 1)!]$ values may be produced by the generalized implicit function rule; just how many depends on which $r \times r$ submatrices of the Jacobian matrix are nonsingular.

Additional properties and possible uses in economics of the conditional partial derivatives await further study. For the purposes of this paper, it is sufficient to have observed that they arise naturally.

Of course, the proliferation of conditional derivatives can be avoided by placing more stringent assumptions on the VEIFR. In his seminal work on the theory of the firm under MP-MF production, Pfouts assumes that the MP-MF production relation is a collection of p technically unrelated production functions,

$$F_1(Z_1, X_{11}, \ldots, X_{n1})$$
$$(14) \qquad \vdots$$
$$F_p(Z_p, X_{1p}, \ldots, X_{np})$$
$$= Z_1 - f_1(X_{11}, \ldots, X_{n1}) = 0,$$
$$\vdots$$
$$= Z_p - f_p(X_{1p}, \ldots, X_{np}) = 0.$$

The Pfouts model places rigid assumptions on the entries in the J matrix that result in unique marginal products, $\partial Z_j/\partial X_{ij}$, and unique MRTs, $\partial X_{ij}/\partial X_{kj}$, being defined. All other derivatives vanish.

The specific VEIFR (14) has the property that input quantities are explicitly allocated to the production of specific outputs, which was a property that the debilitated analysis of Naylor, and of Naylor and Vernon, was attempting to incorporate. Their Kuhn-Tucker analysis could be salvaged, *mutatis mutandis*, if the p-entry VEIFR (14) were substituted for their SEIFR (4) of MP-MF production. Theorem 2 makes clear that no less than p-equations could be utilized in the representation if Kuhn-Tucker methods were to be subsequently utilized, as their analysis requires.

Conclusions

The results of this paper indicate that the apparent generality of the SEIFR of MP-MF production is only an illusion when a few traditional assumptions concerning differentiability of F and nonvanishing of partial derivatives are added as properties of the function. A VEIFR was examined which is more versatile. However, the VEIFR presents new problems in the derivation and interpretation of derivatives usually viewed as marginal products and rates of product transformation and technical substitution.

Twenty years after Pfout's seminal work it appears the profession has yet to provide a general Lagrangian or Kuhn-Tucker analysis of the theory of the firm under MP-MF production. Work to date seems to be a collection of special cases of a potentially more general theory.

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Subjectivity in *Ex Ante* Research Evaluation

C. Richard Shumway

This essay is a critique of research evaluation research. The argument has three main points. First, considerable evidence exists that agricultural research conducted during the era when projects were chosen by diffuse selection systems yielded extraordinarily high returns. Second, it is not obvious that formalized, quantitative, and centralized selection models can be expected to produce higher contemporary returns than decentralized informal mechanisms. This is because all *ex ante* evaluations are intrinsically subjective, regardless of the technique used. Third, the extreme uncertainty surrounding the nonrepetitive, new-knowledge production function further limits the potential of the sophisticated selection procedures. Perhaps of greater importance, however, are the high costs imposed by these procedures in terms of scientists' time, morale, and "artistic" research tool decay.

Purpose of Research Evaluation

Partially in response to the increasingly heavy pressure from federal and state governments for more detailed planning, evaluation, and accountability of public research resources and partially out of a basic academic interest among diverse scientists, much effort in recent years has been invested in devising new methods for evaluating public agricultural research. To wit, three symposia have been devoted to the subject, resulting in the publication of two books (Fishel; Arndt, Dalrymple, Ruttan) and a forthcoming proceedings of the most recent conference.[1]

Reasons for wanting to evaluate research range from measurement of the historical rate of return for research investments to assessment of the influence of various organizational participants on research selection and conduct. However, just as the many and diverse intermediate objectives of economic research ultimately funnel into the overriding end goal of improving predictive performance, so the major objective of research evaluation research condenses to improving predictions of costs and benefits of future research. The ultimate practical objective of all this work is purely *ex ante*, i.e., to provide relevant information for future funding decisions. Determining the productivity of past investments would be mainly academic, since those costs are sunk, except as information is provided, which is also relevant for making variable cost (i.e., present and future) decisions.

Do We Need Formal *Ex Ante* Analysis?

Ex ante evaluation of research alternatives is not a new concept. It has always been conducted in some fashion at one or more levels in the research organizational hierarchy. Historically, the major assessment of project alternatives has been made by the individual scientist acting as an entrepreneur on behalf of his own professional life. Administrators have reviewed proposals submitted by scientists and approved, disapproved, or modified them, but the major administrative roles have been more in trying to increase total funding and in selecting scientists who would be with the organization for extended periods than in selecting individual projects. Of course, the role of administration varies from organization to organization, but few have implemented formal, systematic evaluation procedures for quantitatively measuring the worth of one research area against another.

The justification for proposing a change in the way *ex ante* research evaluation is conducted must ultimately rest on one of the following perceptions: (*a*) the current system is not working well; or (*b*) some evidence exists that even though the current system is working well, it could do significantly better with a change.[2] Let us investigate briefly whether there are sufficient grounds for either perception in agricultural research.

Importantly, the historical rate of return on agricultural research investments provides valuable information relevant to the first possible justification for change. Although some assumptions underlying the various models can be challenged and some of the data used are disquietingly shallow, the high rate-of-return estimates are profoundly robust.

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[1] Symposium on Methodology for Evaluation of Agricultural Research, Minneapolis, May 1980.

[2] A reviewer suggested a third and perhaps the most common reason for proposing a change in *ex ante* research evaluation—budget appropriators insist on a change in the evaluation process before they will appropriate. Actually this is merely a symptom that the appropriators have one of the two perceptions identified in the text.

Nearly all studies have estimated a historical rate of return to agricultural research investments in excess of the average return on industrial capital investments (see Evenson, Waggoner, Ruttan, p. 1103). This is true not only for studies of aggregate U.S. agricultural research investments, but also of U.S. regional investments, foreign investments, and commodity-specific investments. Consequently, unless equity costs of such research have been extremely high, the only plausible conclusion from the rate-of-return studies is that there has been general underinvestment in agricultural research.[3] Some evidence exists that the rate of return on aggregate U.S. agricultural research investments may be decreasing with time (see Peterson and Fitzharris, p. 78; Evenson, Waggoner, Ruttan, p. 1103), but the most recent estimates are still in excess of 20% per year. Thus, underinvestment in agricultural research is still apparent.

With such high estimates of historical rates of return, it is difficult to argue logically that the seemingly loose *ex ante* evaluation procedures used in the past have not worked well. So the first justification for arguing a need for change must be dismissed.

Arriving at a clear conclusion concerning the second justification is not so easy. It is a truism that we can always do better. Unfortunately that truism has little practical value. We are not working with optimum versus suboptimum, because in *ex ante* evaluation the optimum is indeterminate. There is simply too much uncertainty in the nonrepetitive, new-knowledge production function. The primary issue in our evaluation of *ex ante* evaluation procedures is not whether some bad projects have been funded in the past or whether more will be in the future. It is fundamentally whether we will decrease the errors and increase the total payoff from research efforts by changing the evaluation procedure.

Arguments in favor of a change often focus on the benefits of "systematic" evaluations and greater "objectivity." Many of the proposed alternative evaluation procedures are clearly systematic. They permit categorizing, ordering, comparing, and summarizing data in ways that are internally consistent and thus systematic. The question is whether they permit any greater objectivity than the evaluation methods used historically.

Role of Objective Data in *Ex Ante* Analysis

Objectivity is obviously preferred to subjectivity easily defended. It is easier to convince another person of the truth of objective rather than subjective observations. Since the future is unknown and highly uncertain, the only objective data are historical observations. Because methods for measuring the historical research performance have received considerable attention, the use of such historical data is a logical place to begin. If it is possible to correlate with confidence historical research performance with future research payoff at a very micro level, our evaluation procedures could introduce a measure of objectivity that would increase their administrative value considerably.

Within the profession, there is considerable expectation that a scientist who has proved to be highly productive in the past is a good risk for future investments of support funds. Although examples to the contrary abound, there is strong sentiment that historical performance of a scientist is a useful tool for predicting future productivity. Thus, funding agencies continue to invest a large share of their money with proven researchers. There appears to be little risk that investments in a Samuelson or a Friedman will not pay rich dividends.

Unfortunately, no research organization is made up of all Samuelsons and Friedmans. Few have even one. How then can these administrators take advantage of historical information to help them determine which additional research areas to promote and which to reduce?

I have previously proposed a set of four sufficient conditions that would permit the use of historical information at the research area level in objectively predicting future payoff (Shumway, p. 192). The conditions are: (*a*) Proposed projects are competitive for available resources. (*b*) Research technology used on each historical and proposed project is of comparable quality for its time. (*c*) The production function for new knowledge discovery is characterized by an S-shaped (stages 1 and 2 only) production function. (*d*) Each project represents a small movement along the knowledge production function.

These four conditions are sufficient to establish an orderly relationship between past and future research payoff. I have made a defense for each condition, but the defense for conditions (3) and (4) remains the weakest. The likelihood that the new knowledge production function is anything close to a smooth S-shape seems quite low. A less restrictive concave production function would still be sufficient, but it would have to be reasonably smooth. It is the smoothness property that is most

even most, of the applied research of any state or federal agricultural research unit is quite low.[4]

It is true, for example, that breakthroughs in hybrid corn research have had important effects on hybrid grain sorghum and wheat research. But what has been the payoff from recent genetic research on corn? The marginal physical product of genetic research on corn could be characterized more as a few important blips (e.g., male sterile techniques, upright leaves, and high lysine varieties) and one huge blip (hybrids) than as anything close to a smooth function.

While hard scientific data on the subject are lacking, a few case studies document the need to be cautious about overestimating the value of objective data for the *ex ante* funding decision. It appears unlikely that my sufficient conditions will prove very useful. Unless someone identifies another set with a considerably higher likelihood of being met, objective data will continue to play a minor role in *ex ante* research evaluation.

Many casual observers, including some research administrators and even some analysts, mistakenly attribute objectivism to certain evaluation techniques. The fallacy is in equating objectivity with quantifiability. Many techniques do use quantitative and/or qualitative inputs and provide quantitative evaluation outputs, but all *ex ante* research evaluation procedures are inherently subjective. The only difference is where subjectivity enters and how it is processed.

With Q-sort, subjectivity is imposed by the administrator at the highest level of abstraction in grouping projects into categories of similar overall worth. With scoring models, subjectivity determines the specification and weighting of criteria and the categorization of each project relative to each criterion. Only the computation of the overall score proceeds in an "objective" fashion (Moore and Baker). With *ex ante* benefit-cost and rate-of-return estimates, subjectivity is also inherent in the estimates of both research benefits and investment costs (e.g., Araji, Sim, Gardner). The predicted benefit-cost ratio and the rate-of-return estimate are quantified, but they are nonetheless subjective. Formalized optimization models (e.g., Shumway and Hwang) rely on subjective evaluations of the relative importance of objectives, expected achievement of objectives, probability of success, and expected cost. Even Rausser et al.'s recently proposed four-stage evaluation procedure is based almost exclusively on subjective data.

The only contributions any of the formal *ex ante* evaluation techniques can make, whether used at the micro level of the project or at some aggregated level, are to (*a*) permit a formalization of the role of subjectivity, (*b*) suggest collection of objective information on which to base subjective assessments, (*c*) insert subjectivity in forms that are most natural, and (*d*) process subjective data systematically in order to feed back information relevant to the funding decision. They cannot make objective outputs from subjective inputs, no matter how precise and elegant they appear. Consequently, the legitimate role of subjectivity in *ex ante* evaluation needs to be recognized clearly and respected.

Assessment of Formal *Ex Ante* Evaluation Procedures

It is evident that many of the formal evaluation procedures are systematic. It is not clear that they are any more conducive to objectivity than the commonly used methods of evaluation. The fact that systematic evaluation procedures have been recommended to research administrators for at least fifteen years and few have implemented them is strong *prima facie* evidence that their current costs outweigh their perceived benefits.[5]

A quaint but relevant comparison is that if a car is broken, the mechanic tries to fix it. However, if it is running well and is getting better gas mileage and emits fewer pollutants than other comparable cars, he leaves it alone. He does not overhaul it until he has some evidence that it will then perform better.

The agricultural research establishment is not perfect, but it has performed well in the past without formal *ex ante* evaluation techniques. Further, there is no convincing evidence it will perform any better in the future with them. A heavy burden of proof that administrators need sophisticated and formalized *ex ante* research evaluation systems still rests upon the system developers.[6]

Administration-Scientist Synergism

It is entirely possible that efforts to develop relevant evaluation techniques have focused on the

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[4] It is likely that the research production function becomes more stable with increasing aggregation since successes and failures on individual projects tend to average out. However, uncertainty remains great even at the broad research area level, and pressures for more systematic *ex ante* evaluation procedures extend to much lower levels.

[5] This is not to say that such rejection is sufficient evidence to discontinue research on alternative management techniques. The management and information sciences are still in their infancy, and their innovations face generally low rates of adoption in many fields.

[6] I am indebted to Willis Peterson for adding a caution regarding the evaluation procedures used by NSF, NIH, and many other research-funding agencies that are formalized and systematic only in the sense that they rely on formally requested peer reviews. "One should raise the question whether outside evaluators . . . can be expected to give a very good estimate of the probability of success of a project, and if it is successful how much the new knowledge which is produced will be worth to society. Even the evaluation of peers should not be assumed to be superior to the assessment made by the person submitting the proposal. It usually is assumed to be superior, however, because the final decision to fund a project generally is based on peer review and the project author rarely has a chance to reply to the review. If the reviewers do not happen to be working in exactly the same area or if they are partial to a different approach, many potentially successful projects could be rejected."

wrong person. Administrators must make project selection decisions. But the alternatives they select from are formulated mainly by scientists, not by administrators. The organization must have proposals generated by imaginative, capable scientists who are well attuned to the problems of the public and the respective disciplines. Otherwise, administrators have only hollow project selection decisions to make.

A serious potential risk emanates from all the attention given to systematic and rigorous *ex ante* research evaluation. It is possible that greater administrative intervention in project selection will lead to submission of a larger number of proposals but with lower quality research to be conducted on all of them. The larger number of proposals permits administrators to exercise their responsibility of decision making. But, will the quality and quantity of research conducted by the organization be as great as when performed by well-motivated scientific entrepreneurs unencumbered by either the paper requirements or the annoyance of organizational demands for *ex ante* evaluation and *ex post* accountability?

Unless the research organization is going to change scientists more often than any do now, the only relevant research alternatives are those that can be pursued by existing scientists plus a few new ones. Therefore, the appropriate place to begin the evaluation process is with the scientist. How can this entrepreneur be helped to select projects with high potential payoff?

Problem selection is generally the most important and most difficult part of inquiry. It is important because it delimits the range of investigation and establishes upper limits, although undefined, on the potential payoff of the inquiry. It is difficult largely because there are no formal rules by which scientists can learn to ask significant questions leading to the recognition of significant problems. The ability to formulate important problems whose solution may also help solve other problems is often considered to be a rare gift.

Yet, some relevant guides can be identified to assist this learning process and sharpen the subjective perception of relevance. Sources of valuable signals must be cultivated, rational thought processes must be used in serious evaluation, and subconscious intuition must not be throttled.

Research Priority Signals

Only a weak economic market exists for public research products since few products are sold and most are placed in the public domain at little or no charge to the user. However, an obvious source of research priority signals is still the market system. There is a strong economic market on the resource side of research, i.e., the job market. Bids and offers for particular scientists largely reflect a perception of the relevance, quality, and quantity of their work. While such offers are determined primarily by intermediate research products (i.e., publications), they are proxies for anticipated value of the final products to society.

Market signals also come from the user in the form of legislative support or lack of support for research budgets. If the political processes work smoothly, legislators will reflect the attitudes of a majority of their constituents. Thus, the budget message is an economic signal from the end-product market to research administrators. Administrative priorities in turn become proxies for public preferences.

While these economic signals are important, they are not sufficient for *ex ante* evaluation because either they are not sufficiently specific or they are based on assessments of work already completed. Additional sources of signals need to be cultivated. Strong two-way bridges of communication between research and extension are important to permit flow of current societal priority signals to researchers as well as new knowledge to users. The scientific community has a responsibility also to address problems not yet faced by society and to build the theoretical structure and analytical tools to deal with them when they do occur. Reading, professional meetings, and interaction with other scientists can hone the scientists' perception of such theoretical research priorities.

Project Selection by the Scientist

With good communication among colleagues, competent scientists always will be aware of far more interesting and important research problems than can possibly be addressed. The next challenge is to propose a set of prioritized projects to the administration that the scientist considers to have the highest payoff. It is unlikely that the scientist will find quantitative evaluation models useful for this purpose, but a few simple questions might be helpful. For example:

(*a*) Who is your clientele?

(*b*) What are your priorities as to audience service (e.g., policy makers, researchers, farmers)?

(*c*) To whom is the problem important?

(*d*) To how many is the problem important?

(*e*) How much benefit will the clientele receive if this problem is solved?

(*f*) Do you have the analytical tools to conduct the research?

(*g*) What is the likelihood that your research effort will provide (or at least contribute to) a solution to the problem?

(*h*) What are the expected research costs (money and time)?

(*i*) What are the expected implementation costs?

No weights are suggested. Answers to these or similar questions help to identify weak links in the proposed study and promote communication between scientist and administrator. It is possible that the scientist's answers to questions (*a*) and (*b*) may be different than his administrator would like them to be, but explicitly defining them can be valuable in uncovering differences that could remain undefined

and become a source of confusing interaction between the two.

"Artistic" Considerations

Because identification and pursuit of significant research problems is not an exact science, the role of nonobjective research tools also needs to be addressed. In a recent article, Ladd identified some of the most frequently used, versatile, and valuable research tools, none of which lend themselves to formal incorporation in a quantitative *ex ante* project evaluation model. They include the subconscious mental processes of imagination, intuition, and hunch, the unpredictable role of chance and serendipity, and the stimulating effects on the subconscious and on research efficiency from writing. These artistic tools probably are at least as important to productive research as are the orderly and systematic thought processes. Consequently, whatever procedures are considered to assure *ex ante* evaluation and *ex post* accountability ought to be weighed carefully against any possible negative impact on these valuable research tools.

Conclusions

Five concluding recommendations are drawn from this attempt to elaborate the relevance of subjectivity in *ex ante* research evaluation:

(*a*) Let us be realistic about the contribution formal research evaluation techniques can make. No more should be promised than can be delivered. Quantification is not synonymous with "better." Negative impacts on scientist morale, ambition, and imagination must be weighed carefully against any expected benefits from increasing the planning, evaluation, and accountability functions of the organization.

(*b*) Because the search for new knowledge is laden with heavy risks and many dead ends, it may be unwise for a research organization to establish a single, overriding objective. An individual researcher may be single-minded, but perhaps the organization should deliberately be a little schizophrenic and simultaneously pursue conflicting goals in order to be prepared for changing conditions.

(*c*) The prominent place of subjectivity in *ex ante* evaluation needs formal recognition and respect. Just as quantification does not mean better, neither does it imply objectivity. Any *ex ante* evaluation is intrinsically subjective. Objective historical observations may be relevant, but the linkage between past and future knowledge generation is sufficiently weak to require gross subjective synthesis and assessment.

(*d*) Instead of worrying about dividing an existing pie among many competitive alternatives, let us concentrate on educating administrators how to use historical data relevantly. Historical rate-of-return estimates are sufficiently high and robust to imply that the major deficiency has not been in allocation but in level of overall investment. It seems clear there has been public underinvestment in agricultural research.

(*e*) The role of the individual scientist in *ex ante* evaluation warrants considerably more attention. Without his/her generation of ideas and aggressive pursuit of interesting problems, the research organization would stagnate regardless of the valiant efforts of the administration. The scientist is the first and most important participant in the research evaluation process and is fundamentally concerned with and involved in project selection. Evaluation techniques which do not recognize that crucial linkage or which demand additional effort from the scientist in documentation and accountability for the system's sake are doomed to dismal failure.

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Choices and Consequences: Comment

Richard Green and Zuhair A. Hassan

King in his July 1979 presidential address to the Association discussed some problems facing economists in the selection of a proper analytical approach and the evaluation of consequences from these choices for decision makers. To illustrate his points, he cited works by Green, Hassan, and Johnson; and Hassan, Johnson, and Finley. Three areas of major concern were mentioned: (*a*) formulation of hypotheses tests, (*b*) changing elasticities over time, and (*c*) the relationship between price and income elasticities in complete demand systems. In this comment we respond to the first and third problem areas in demand analyses as identified by King. The objective is to place some of the critical statements in perspective. A discussion of changing elasticities can be found in Hassan, Johnson, and Finley, and the subsequent exchange with deJanvry.[1]

The literature contains a number of studies reporting on the estimation of utility-function-based demand systems, such as the indirect addilog model, the translog model, and the linear expenditure system (LES). Each system is not without its limitations, and there are associated costs with choosing any complete demand system. The translog system, for example, is data-demanding since a large number of parameters must be estimated. The LES and the indirect addilog, on the other hand, are derived from additive utility functions. This behavioral restriction implies strong restrictions on substitution possibilities. Of course, the selection of the model must be guided by the benefits and costs weighed in the context of the problem at hand.

The "take-home message" of this discussion is that in applied work, the choice of any model implies certain undesirable consequences for the user. And in particular, in applied demand analyses, whether to use a single-equation approach or a systems approach and which alternative functional representation to employ is a judgmental decision that always leaves the economist in a vulnerable position. The hope is that the authors conducting the research are aware that models are to be used, not believed (Theil, p. vi).

Referring to King's specific criticisms, we consider first the question of proper hypothesis formulation. Instead of testing that the marginal budget shares are equal to zero, King suggests that a more proper test would involve whether the marginal budget shares (MBS) differ from the average budget shares (ABS) at the mean or otherwise specified income levels. This information is already available in the estimated income elasticities since they equal the ratio of the marginal budget to average budget shares. A value of the income elasticity greater than one implies that the MBS is greater than the ABS and a value less than one implies the reverse. Thus, information equal in quality to that provided by King on this hypothesis can be obtained simply by inspection of the magnitudes of the income elasticities. The tests called for, however, require more rigor than is implicit in the data presented. More specifically, standard errors associated with the income elasticities must be calculated, and in some complete demand systems the variances of the sampling distributions of elasticities have not been explicitly derived. An investigation of their statistical reliability through formal tests of significance is then hampered to a large degree.

Perhaps the most serious limitation of the LES, which was pointed out by Deaton, is the approximate relationship of proportionality between income and price elasticities. This property is referred to as Pigou's Law because he was the first one to discover the relationship for additivity demand models. King (p. 845) states that, from this relationship, it can be demonstrated that the LES requires income elasticities to be larger than price elasticities, and the latter must lie between 0 and -1.0. Neither one of these assertions is true. If negative marginal budget shares are allowed—and Deaton (p. 30) does not rule this out a priori, although he recognizes it creates some difficulties—it is possible that negative income elasticities can be obtained that are algebraically less than price elasticities. However, these conditions would imply a violation of the nonsatiety axiom of demand theory (Powell, p. 38). An anonymous reviewer also pointed out that it can be shown that the LES can produce elasticity estimates comparable to Wold and Jureen's rule if some or all of the minimum subsis-

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S. R. Johnson and an anonymous reviewer provided helpful comments on an earlier draft of this comment.

[1] At issue was the question of whether the models were approximations to the true system. Our position was that the models were approximations and that it was of interest to examine possible changes in elasticities implied by the grossness of the approximation. Had we to do this analysis again, we would have used, instead, a variational parameters hypothesis directly assessing the changing elasticities.

tence quantities, γ_i, are negative. In addition, price elasticities in the LES can be greater then one in absolute value if the "minimum subsistence quality," γ_i, is negative. Theory does not rule out a negative value for γ_i, and negative estimates for γ_i have been obtained under certain conditions. But the most important consideration is how serious a consequence does this property of the LES inflict upon empirical results? Does this make the static LES completely unusable for food policy evaluation purposes, as King (p. 846) suggests? Let us explore this question a bit further.

King comments that earlier works of Brandow, Waugh, and George and King found price elasticities for food commodities (necessities) greater than income elasticities for food in accordance with Wold and Jureen's rule. That rule states that income elasticities of necessities are smaller than their price elasticities, whereas income elasticities of luxuries are greater than their price elasticities. Several observations are in order here. First, the earlier works cited by King obtained price and income elasticity estimates using some rather ad hoc procedures. Block additivity was assumed, extraneous estimates were introduced as known with certainty, etc. Consequently, from an econometric viewpoint these earlier estimates might be held suspect, especially as they relate to food groups. Second, Deaton, who is slightly critical of the LES for the "Pigou" relationship, estimates a double-log model using the same data. It is interesting to note (p. 69) that, although the proportionality result is not reflected in the estimated price and income elasticities, he did obtain income elasticities for many commodities that would be considered necessities, including food commodities that were larger than their associated own-price elasticities (pp. 70–77). Many other empirical studies indicate similar conclusions, which implies that Wold and Jureen's rule, although intuitively appealing, is unambiguously true only for the two-commodity case. The rule does not necessarily hold for complete demand systems. In addition, the assumption of additivity is defensible if the arguments of the utility function are taken to be broad aggregates of commodities such as food and clothing, rather than individual commodities such as beef or cheese. A recent article by Klevmarken shows that the LES compared with nonadditive models in terms of goodness of fit, predictions, and comparisons of elasticities.

What is the main conclusion that can be reached from this examination of choices and their consequences in a demand context? We think that the primary one is that in applied demand analysis (or, more generally, applied economic research) any choice of a model has trade-offs. Thus, any policy statements made from the empirical results should be recognized as reflecting the limitations of the theoretical model and the econometric procedures used. This is not to say that applied demand analysis is not useful to policy makers, but rather that research results must be used with knowledge of the assumptions and weaknesses of the methods employed. Finally, we disagree in the specific conclusions reached by King concerning use of additive demand models, especially when limitations of alternative procedures are fully taken into account. We applaud his attempt to be scholarly but feel that he has failed to recognize that all models are but approximations of underlying systems. We should not be surprised that the approximations, likely developed with certain purposes in mind, do not yield desirable characteristics of all features of the system.

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Choices and Consequences: Reply

Richard A. King

In their "Comment," Green and Hassan note that the choice of a model involves trade-offs, that model results are to be used rather than believed, and that a single model may not be best for all purposes. These points cannot be stressed too often. However, they raise a number of concerns that warrant further clarification.

Green and Hassan have managed to smoke out the real reason I selected the example of simultaneous demand systems when discussing the general problem of identifying benefits and costs of alternative models. The reason is simply that the results reported by many economists using these models seem implausible to me. I set out to discover why these models produce estimated income elasticities that are consistently higher than the absolute value of direct price elasticities.

The result of this search was to uncover what I believe to be previously unrecognized constraints on elasticities that are inherent in many complete demand system models. Perhaps my explanation of how empirical demand elasticity estimates are constrained in these models was unclear. A more complete explanation of those constraints may help to settle several points at issue. The linear expenditure system (LES) is selected for this purpose.

Consider first the relationship between income and price elasticities. Green and Hassan suggest that the most serious limitation of LES models is the approximate proportionality between the two (Pigou's Law). It is my opinion that constraints on the absolute size of income and price elasticities are more serious in view of the violation of Wold's rule that, in general, price elasticities for necessities should be larger than income elasticities, and price elasticities for luxuries should be smaller than their associated income elasticities.

Green and Hassan state that I was in error in arguing that LES income elasticities must be larger in absolute value than price elasticities. The qualification that must be added to make this a correct statement is that price elasticities are assumed to be nonpositive. In fact, it can be shown that if price elasticities are positive, then income elasticities must be smaller than or equal to price elasticities. This occurs when negative marginal budget shares are encountered for the group in question, implying a violation of the axiom of nonsatiety, as noted by Deaton. That possibility requires a modification of my figure 3c as shown below (figure 1). It is true that all elasticity estimates must lie to the right of the diagonal line AB.

To evaluate LES model constraints on price elasticities, it is necessary to establish appropriate limits on the range of the minimum subsistence quantities, γ_i. The absolute value of price elasticities can be greater than one if γ_i is negative. Although negative values of γ_i are not ruled out on theoretical grounds, it is possible to do so on other grounds. Unless all group expenditure functions pass through the origin (all $E_i = 1$), some will have a positive expenditure axis intercept while others will have a negative intercept. It is the latter that have negative γ_i values over the lowest ranges of income. However, all such values of income are smaller than M_s, the minimum subsistence income. (M_s demarks the level of income above which no group expenditure function lies below the income axis.) Let us rule out the possibility of sales by households, which would allow expenditures on other groups to exceed income, M. This is done by the appropriate identification of M_s and is equivalent to requiring non-negative values of the minimum subsistence quantities, γ_i, as shown in my 1979 paper (p. 842).

We now investigate in more detail the constraints on direct price elasticities. Following Green, Hassan, and Johnson (p. 94), we write the LES individual expenditure function for group i as

$$(1) \qquad p_i q_i = p_i\gamma_i + \mu_i\,(M - \Sigma p_i\gamma_i),$$

where $p_i\gamma_i$ is expenditure on i at minimum subsistence income, M_s, and M is total expenditure $\equiv$ income. Let $M_s = \Sigma p_i\gamma_i \equiv$ minimum subsistence income, and $M_n = M - M_s \equiv$ supernumerary income. We rewrite (1) as

$$(2) \qquad p_i q_i = p_i\gamma_i + \mu_i M - \mu_i M_s.$$

If we combine the first and third terms in (2), we have the expenditure axis intercept term,

$$p_i\gamma'_i = p_i\gamma_i - \mu_i M_s,$$

and the expenditure function (1) can be written as

$$(3) \qquad p_i q_i = p_i\gamma'_i + \mu_i M,$$

where μ_i is the constant marginal budget share such that $0 < \mu_i < 1$ and $\sum_i \mu_i = 1$.

Again following Green, Hassan, and Johnson (table 1, p. 95), we write the LES equation for direct price elasticities as

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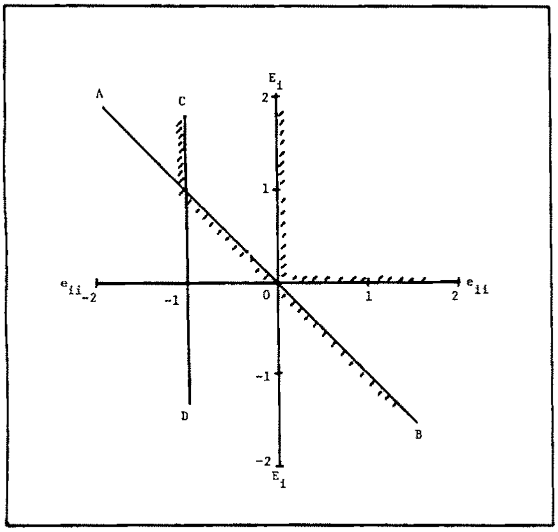

Figure 1. Relation between price elasticities (e_{ii}) and income elasticities (E_i), LES model

$$e_{ii} = -1 + (1 - \mu_i)\,\gamma_i/q_i. \tag{4}$$

Given that γ_i and q_i are non-negative in the relevant range of income, with

$$q_i \geq \gamma_i \text{ and } 0 < \mu_i < 1,$$

it follows that the second term lies in the range

$$0 \leq (1 - \mu_i)\,\gamma_i/q_i < 1.$$

Thus, the direct price elasticities are constrained to lie in the region $-1 \leq e_{ii} < 0$. As M rises, the ratio γ_i/q_i approaches zero and e_{ii} approaches -1. Direct price elasticities thus are constrained to the region between the vertical axis and the line CD (fig. 1).

We next investigate the size of E_i relative to e_{ii}. Changing the sign of e_{ii}, we evaluate the following:

$$E_i \gtrless -e_{ii}. \tag{5}$$

We write (5) as

$$\frac{\mu_i}{w_i} \gtrless 1 - (1 - \mu_i)\frac{\gamma_i}{q_i}, \tag{6}$$

where $w_i = p_iq_i/M$. We rewrite (6) as

$$\frac{\mu_i M}{p_iq_i} \gtrless 1 - \frac{\gamma_i}{q_i} + \frac{\mu_i\gamma_i}{q_i}, \text{ or} \tag{7}$$

$$\mu_i M \gtrless p_iq_i - p_i\gamma_i + \mu_ip_i\gamma_i. \tag{8}$$

But, from equation (1) we know that

$$p_iq_i = p_i\gamma_i + \mu_iM - \mu_i\Sigma p_i\gamma_i.$$

Substituting this relation in (8) produces

$$0 \gtrless p_i\gamma_i - \Sigma p_i\gamma_i. \tag{9}$$

Since $p_i\gamma_i \leq \Sigma p_i\gamma_i$, it follows that

$$p_i\gamma_i - \Sigma p_i\gamma_i \leq 0.$$

Therefore $E_i \geq -e_{ii}$, thus violating Wold's rule for necessities as illustrated in figure 3c of my paper (p. 844). Green and Hassan give no reason for suggesting that increasing the number of commodities would change the finding that LES price elasticities must be smaller than income elasticities and lie between 0 and -1, surely a matter of some interest to users of empirical demand estimates.

We have assumed thus far that each marginal budget share, μ_i, is positive and smaller than one. If equal to zero, it follows that income and price elasticities are equal to zero. If negative, it follows that income elasticity is negative, the corresponding price elasticity is positive [see eq. (4)], and the absolute value of income elasticity is smaller than price elasticity. Changing signs on both sides of (5) reverses the inequality found in equation (9). For obvious reasons, this latter case is of little empirical interest.

Under what circumstances is a simultaneous demand systems model (e.g., indirect addilog, translog, LES) to be preferred over a "sequential" (ad hoc?) estimation method of the Brandow and George-King variety that weaves together bits of information from a variety of sources? The benefits deriving from the first alternative are fairly clear, but users may not recognize fully certain undesirable consequences, other than the need for large data sets, that are incurred in the process, a point that I intended to stress in my Pullman paper. Appeal to the utility function foundation of demand systems models may or may not be persuasive, depending on one's tastes in the matter.

As for appropriate hypotheses, of some interest is the question of whether there is any reason to regard various commodity groups as differing in response to changes in income. The notion that one should substitute an eyeball test of the size of income elasticities reflects a lack of imagination, to say the least. Budget weight is known and standard errors of the marginal budget shares are reported.

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Books Reviewed

Goodwin, Geoffrey, and James Mayall, eds. ***A New International Commodity Regime.*** **New York: St. Martin's Press, 1980, 237 pp., $25.00.**

The developing countries proposed an Integrated Commodity Program (ICP) as part of their call for a New International Economic Order (NIEO) at the Special Session of the United Nations General Assembly in Algiers in 1974. The ICP was at the heart of the call for an NIEO. Responsibility for drawing up a proposal was entrusted to UNCTAD. At UNCTAD IV in 1976 approval was given to proceed with explorations for an ICP for ten core commodities (coffee, cocoa, tea, sugar, natural rubber, sisal, cotton, jute, copper, and tin). The integrated dimension was to be provided by a Common Fund (CF) of $6 billion, the primary purpose of which was to finance agreements for the core commodities, and the secondary purpose of which was to undertake a series of activities to aid nonstorable commodities of importance to the developing countries.

This book brings together seven papers on the ICP which grew out of a seminar on the topic sponsored by the Center for International Studies at the London School of Economics and Political Science (LSE) in 1976–78. It attempts to present a broad perspective regarding not only the political and economic aspects of the debate, but also the role of the private sector in the form of international commodity markets and direct foreign international investment. The presentation is verbal, without undue recourse to technical jargon.

This book is divided into two parts. Part I attempts to provide background. Chapter 1, "The Pressures for a New International Commodity Regime" by Mayall (LSE), describes and analyzes the political evolution of the call for an ICP and CF, the anatomy of the Group of 77 (i.e., the developing countries), and the question of legitimacy and management in North/South economic relations. Chapter 2, "The Case for a New International Commodity Regime: Confused Arguments and Unresolved Issues" by Stuart Harris (Trade Policy Research Center, London and Australia National University), summarizes existing international economic arrangements and arguments about the nature of present international commodity markets and the impact of proposed changes. Chapter 3, "The Current State of International Commodity Negotiations" by Alister McIntyre (UNCTAD), briefly describes negotiations on the CF and on individual [illegible] dices consider the nature of international commodity markets for wheat and coarse grains, tin, and copper.

Part II focuses on the industrialized countries' responses to the proposed ICP and CF and on the role of the private sector in the international commodity markets. Chapter 4, "The OECD Industrialized Countries' Response" by Goodwin (University of London), traces the evolution of reactions to the UNCTAD ICP proposal and the underlying causes thereof in the United States, Federal Republic of Germany, United Kingdom, Japan, and (much more briefly) other developed countries. Chapter 5, "The Scope for Co-Cooperation Between Existing Market Institutions and International Commodity Agreements" by James Fry (Commodities Research Unit, London), presents interesting analyses of interaction between commodity agreements and existing spot and future markets (e.g., London Metal Exchange) and how such interactions would constrain and expand the options available to managers of commodity agreements. Chapter 6, "Mineral Exploration and Third World Policy Towards the Mining Industry" by Brian Hindley (LSE), is a thoughtful analysis of the problems in designing contracts between host developing countries and potential mineral explorers and investors in a world of uncertainty and of the costs incurred by a number of developing countries through insisting on contract unenforceability (and thus discouraging subsequent investments) or service contracts (in which they assume all risks). Chapter 7, "Private Sector Investment and Political Risk: A Comparative Study of OPIC and Other Schemes" by Ronald K. Shelp (American International Group), describes recent operations of (largely industrialized government) insurance schemes for political risks for investments in developing countries.

I have reservations about some aspects of this book. At times some of the "facts" do not seem right (e.g., that among the UNCTAD commodities only coffee, cocoa, sugar, and tin have low price elasticities of demand (p. 30) or that Indonesia is among "the more advanced developing nations," p. 225). Sometimes the analysis is not sufficiently updated for a book published in 1980 (e.g., on p. 90 there is reference to the "current price"—for January 1977). The three appendices on "representative commodities" (p. 7) do not include even one of the UNCTAD core agricultural commodities. Occa-

sidered sufficiently in a book which purports to place special emphasis on the role of the private sector.

But despite these reservations, I think that it is a useful book. It generally is well-written, with efforts to integrate the material somewhat across chapters. Several of the chapters are particularly useful in providing a broad perspective on the context of the debate on the ICP and CF and related issues (e.g., those by Mayall, Harris, Goodwin, Fry, and Hindley). The broad perspective which it provides complements well other good recent studies of ICP's, the CF and the NIEO[1] and thus contributes to a better understanding of the issues and possible resolutions in this important area.

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Guither, Harold D. *The Food Lobbyists: Behind the Scenes of Food and AgriPolitics*. Lexington, Mass.: D.C. Heath Co., 1980, 358 pp., $27.95.

A widely held view in recent years is that a new agenda has evolved for farm and food policy makers. Now, along comes Professor Harold Guither of the University of Illinois to explain that, in addition to a new agenda, there are new actors participating in the policy-making process.

His book, in some ways untraditional for a professor of agricultural economics, with its foreword by Congressman Paul Findley, was written "to identify and briefly describe the many organizations and groups that have had vital interests and concerns about federal government decisions in some phase of agriculture, food production, and distribution in the late 1970's."

After naming the official cast that manages the federal policy-making process, Professor Guither goes on to review a wide range of interests that influence the design and conduct of federal farm and food policies. His presentation, in general, left this reader feeling that the influence of these organizations and groups is growing and may eventually exceed that of the more traditional farm organizations.

An interesting extension of this section is an appendix that lists food- and farm-oriented groups that made contributions to political candidates in 1977–78 through political action committees, the established mechanism for giving financial support to political candidates. Included on the list are the number of candidates supported from each party and the total amount of contributions by each organization. Of some note because of their minimal contributions were the major farm organizations. Of some note because of their sizeable contributions were the dairy cooperatives, the rural electric cooperatives, and, as farmers have long suspected, the boards of trade and mercantile exchanges. The surprise relative to the latter group was the near-balance reported in the number of candidates supported from each major political party.

While the major farm organizations did not appear strong in the contributions area—only the American Farm Bureau Federation had established political action committees—this reviewer was surprised, in some ways pleasantly, by another particular activity carried on by a major farm organization. The National Farmers Union is the sponsor for the federally financed Green Thumb Program which "hires and finds jobs for low income men and women fifty-five years old and older in rural areas." The program, administered for NFU by former Assistant Secretary of Agriculture John Baker until he retired in 1979, was first funded by the Department of Labor in 1974 with $3.6 million. With a growth rate that must set a record for a rural development-type program, it reached $72.2 million in 1979.

While Professor Guither found concern on Capitol Hill over the rapid budgetary growth for this "greenback" program, this reviewer found it interesting for other reasons. During this same period, Land Grant Universities were struggling to keep their academically oriented rural development programs alive. Further, monthly unemployment figures released during this period by the Department of Labor consistently showed teenage blacks as the most significant structural unemployment problem for the nation. It is probably best left to others to unravel the message in this experience relative to the oft-heard "waning influence" of farmers and farm organizations and to the importance of individual and organizational leadership in solving urban and rural problems.

Another part of this book, and one that perhaps explains why Congressman Findley claims he will keep a copy near his desk, is a 140-page directory that lists organizations and firms that have an interest in food and agricultural policy, and gives other useful information such as founding dates, sources of funding, size of membership, and names of registered Washington lobbyists. The organizations and firms range alphabetically from Abbotts Dairies—a subsidiary of Fairmont Foods—to The Zuñi Indian Tribe of Zuñi, New Mexico.

Finally, a book like this raises many questions. One is whether or not large numbers of lobbyists may insulate policy makers from their constituents and contribute to the feeling that the government is unresponsive to the people. A second question relates to the view implicit in this book that the name of the game for policy makers is getting reelected: If true and if campaign finances are the key, can a major farm organization that only promises a declining number of votes expect to have an important role in shaping future farm and food policy? A third

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[1] For example, see William R. Cline, ed. *Policy Alternatives for a New International Economic Order: An Economic Analysis.* New York: Praeger Publishers, for Overseas Development Council, 1979, and the many references therein.

and final question is whether growth in numbers of lobbyists leads to growth in staff of policy-making offices, or perhaps the reverse? Of course, it may not be simple causality but rather a simultaneous process spurred on by exogenous or endogenous influences. In either event, it creates a demand for trained staff, and that should create a demand for this book even without the usefulness that I would anticipate most classroom policy teachers would find for it.

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Harl, Neil E. *Agricultural Law*. New York: Matthew Bender & Co., multivolume set, $60.00 per volume.

Will Rogers once said, "Everytime a lawyer writes something, he is not writing for posterity, he is writing so endless others of his craft can make a living out of trying to figure out what he said."

If Will Rogers had the opportunity to read Neil Harl's *Agricultural Law*, his opinion of the writing lawyer would change. First, Harl has written for posterity. In fact, this multivolume treatise is likely to be used as a legal reference well into the next century. Second, it is not difficult to "figure out" what Neil Harl says. His writing skill is well known and is truly exhibited in this monumental undertaking.

Harl's *Agricultural Law*, in the tradition of the legal treatise, is no mere book. It is a well-conceived and planned multivolume set. The original publication plans called for a ten-volume set, but at present fifteen volumes or more are contemplated. Each volume contains from 600 to 1,000 pages. About half of the set has been published, and the remainder will be released as volumes are completed over the next few months. As is typical for a legal treatise, the set will be updated continually (for an annual charge). The set cover is specifically designed to permit insertion of page revisions and "pocket part" supplements as necessary.

The treatise covers the entire gamut of agricultural law, ranging from business organizations to the Uniform Commercial Code. The early volumes include thorough coverage of the topics of civil liabilities, environmental law, labor law, income taxation of farmers, social security, federal unemployment tax, and estate planning. Topics in later volumes include business planning, government regulation of agriculture, state and local regulations, antitrust, commercial law, property law, insurance law, and agricultural cooperatives.

The set serves as an excellent research tool, in that each section is extensively annotated and footnoted. (In fact, many pages contain more footnotes than textual content.) Each section contains thorough discussions of statutes, both federal and state, case law, and administrative regulations pertaining to agriculture.

Matthew Bender and Company has a long and respected history of successful legal treatises in specialized fields. Harl's *Agricultural Law* is likely to be one of the most successful of these efforts. This work will appeal not only to the academician working in any of the fields of agricultural law but also to the legal practitioner who represents farm, ranch, or agribusiness clientele. The rural attorney will find that this treatise provides thorough coverage of a majority of the areas most likely to be confronted in practice.

The field of agricultural law has been expanding rapidly in recent years. Most agricultural economics departments have on staff one or more persons with legal training. Several law schools now offer one or more courses related to agricultural law. More practitioners recognize the special legal problems of agricultural clients, and a number of state and national bar associations have conducted continuing legal education programs relating to the legal problems of farm and rural people. This expansion has been accompanied (but at a slower rate) by some additional literature related to agricultural law. For example, *The Agricultural Law Journal* was launched in 1979 as a quarterly source of agricultural law information. A number of books are being developed for use in undergraduate and law school agricultural law courses and as potential research references. None of the books or treatises presently available or now underway will be as comprehensive as Harl's. Indeed, they are not designed to compete with but to complement this monumental effort.

In Will Rogers' remarks concerning the writings of lawyers, he added, "One level headed smart man could interpret every law there is." Neil Harl has come close to doing just that in *Agricultural Law*—at least for those areas of law impacting agriculture.

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Paarlberg, Don. *Farm and Food Policy: Issues of the 1980s*. Lincoln and London: University of Nebraska Press, 1980, viii + 338 pp., $16.50.

The purpose of Paarlberg's book "is to identify the issues of farm and food policy . . . to report the known facts, to outline the alternatives, to foresee the probable alignment of various interested parties, to estimate the relative strength of the contending groups, and, if possible, to anticipate the outcome" (p. vii). Paarlberg's premise is that agriculture is losing its uniqueness and political power, which he measures in terms of the ability to control the farm policy "agenda." Modern technology and communications have eroded the distinctions between farmers and nonfarmers. Technology has reduced the number of farmers and consequently

their political clout. Ironically, the land grant colleges, which were established to serve agriculture's uniqueness, have been a major force in destroying that uniqueness.

Paarlberg believes the big commodity programs are in jeopardy because the public perceives food prices as being too high rather than too low and perceives commodity programs benefitting big farmers rather than small farmers. Because agriculture has lost political power, farmers will find it less risky to compete in the market than in the Congress.

After reviewing the old agenda of agricultural development and commodity programs in the first 60 pages, Paarlberg addresses the new agenda in the remaining 250 pages. Dating from the mid-1960s, the new agenda items have arisen from a diverse group of nonfarmers who had not previously been prominent in farm policy and who formed "the new zealous coalition with its food stamps, environmental programs, consumer issues, and rural development" (p. 63). Some of these eighteen new agenda issues, as reflected in the chapter titles, are "Price Control," "The Consumer Movement," "Domestic Food Programs," "Environmental Protection," "Prime Agricultural Land," "Energy and Food," "The Future of the Family Farm," "Is Zero Tolerance Tolerable," "The Great Thirst," "Agribusiness and the Restraint of Trade," and "International Food Aid."

Those who have heard Paarlberg speak will recognize the themes: "Agriculture Loses Its Uniqueness" (chap. 2) and "The New Agenda" (chap. 5). But, the book is not a collection of old or undelivered speeches or reminiscences. It is a sagacious evaluation of issues spiced with strategic suggestions. Paarlberg draws upon 500 references and four decades of experience as a Purdue University professor, White House special assistant, Director, Food for Peace, Assistant Secretary of Agriculture, and Earl Butz confidant.

His basic advice is to de-escalate the issues by searching out the facts, seek a common ground of understanding, and work out trade-offs. He concludes with this paragraph: "For a hundred years farmers held the policy initiative. They called the signals, moved the ball, and put points on the scoreboard. But sometime during the past fifteen years there was a turnover. Like it or not, farmers must now play defense. There is one thing worse than losing the ball; that is to lose the ball and think you still have it" (p. 308).

The book is exceptionally well-written in an easy-to-read, nontechnical manner. There are a few tables and charts but no diagrams. Almost every page contains a phrase one is tempted to cut out and paste on the wall. I call them "Paarlberg's Proverbs." Here is a sampling: "The worst thing to do is to listen to the rhetoric, which is likely to reflect circumstances that have become increasingly obsolete" (p. 12). "When the economist enters the world of policy, he must modify his assumption of frictionless and painless change or he too will feel the heat" (p. 31). "Experience shows that events are more influential in shaping farm policy than are previously stated positions" (p. 54).

There are three modest criticisms I might raise. First, more emphasis might have been given to agricultural technology and food demand prospects and their implications for policy. Second, Paarlberg probably overstates the ability of the market to solve the farm problem. He argues that overproduction is largely caused by market incentives. Neither market imperfections (externalities, economies of scale, uncertainty, immobilities), nor nonmarket phenomena (public agricultural research, agricultural fundamentalism, myopic politicians), play a significant role. Third, Paarlberg's arguments in support of food programs, regulation of agribusiness, environmental controls, etc., are not as persuasive as they might be. As a "traditionalist" (p. 9), his perspective and sympathy are closer to the old agenda than to the new one.

But, these weaknesses are more than offset by the book's strengths. I recommend it for undergraduate or graduate policy courses. I also recommend it to all those interested or involved in U.S. farm policy. In my opinion, the book will be quite influential and will become a classic.

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Penson, John B., Jr., and David A. Lins. ***Agricultural Finance—An Introduction to Micro and Macro Concepts.*** **Englewood Cliffs, N.J.: Prentice-Hall, 1980, 546 pp., $18.95.**

Agricultural finance owes its identity as a sub-discipline of agricultural economics largely to Murray's textbook, first published in 1941, and revised six times by other authors over the past forty years. In recent years several world events, particularly the unchecked price inflation of the 1970s, have worked together to create demand for textbooks which can deal with a variety of problems in the financing of agriculture (farming). The text by Penson and Lins is, in some ways, the most comprehensive treatment to date of this still emerging sub-discipline. It may be viewed as another step in the advance of agricultural finance as something more than an offshoot (or subset) of farm business management.

The book is organized into four parts: (*a*) an introductory chapter on the scope of agricultural finance, (*b*) eleven chapters (278 pages) on farm financial management, (*c*) six macrofinance chapters (139 pages), and (*d*) five chapters (98 pages) on financial intermediaries serving agriculture. The organization, other than the additional macro chapters, is essentially similar to that found in other agricultural finance texts. However, in several chapters, the degree of abstractness, and perhaps the detail, seems to be beyond what students can

comprehend adequately in an introductory agricultural finance course. This is especially true of some portions of the chapters (4 and 5) on firm growth and capital investment. Mathematical notation in chapter 5 and in the chapter on the cost of capital (8) is unorthodox at best. It could be confusing to students, even those who have learned the standard notation of the mathematics of finance.

The two "macro chapters," on a national financial accounting system (13 and 14) and the following chapter on capital intensification and utilization in U.S. agriculture, demonstrate the authors' finest skills. Their firm grasp of this area of agriculture is summarized at its best. In contrast, the chapter on explaining aggregate investment and financing behavior (16) somehow just does not click. It tends to betray the objectivity and clarity of expression achieved in chapters 13–15. Perhaps this is due to the subjective, hypothetical nature of the chapter's content—a point the authors themselves make on its opening page.

Chapters on monetary and fiscal instruments and policy (17 and 18) are more-or-less tacked on to the other "macro chapters." The policy instrument chapter (17) could be more appropriately grouped with those on financial intermediaries (part four). The policy action chapter (18), as the authors admit, is devoted almost entirely to manipulations of parameters within the standard Keynesian model. What purpose does this serve as a separate presentation in an introductory or intermediate-level agricultural finance text?

To the authors' credit, the concise treatment of risk in capital investments is handled separately in chapters 6 and 7. In an introductory course, this makes it easier for instructors who elect to scan such material. Those who elect to cover such material in more depth in an intermediate-level course may wish to use such separate chapters for review purposes.

Chapters on legal considerations, business organization types, income tax management, and estate planning (9–12) also seem to be more complex than students enrolled in an introductory course should be required to assimilate. This complexity, or attention to detail, is woven throughout the narrative, thus largely precluding class assignments of only portions of a chapter. For example, the income tax chapter tends to focus on describing the current IRS code and attendant forms rather than outlining and explaining the basics of farm income tax management.

Perhaps the authors are most open to criticism in their treatment of capital investment and capital costs (chapters 5 and 8). However, the deficiencies in these chapters are not uncommon in the agricultural finance literature. If one demands an accurate, clear, and more complete treatment of these topics he (she) must turn to a text on capital investment analysis. A complete treatment of the topics obviously is not possible in only two chapters. What is expected, though, is a fairly clear treatment. But clarity is not found in several places; even accuracy is lacking in parts of the capital cost chapter.

When discussing add-on loans, the authors incorrectly explain how to partition each period's loan payment into a part for interest and the remaining part for principal. Constant interest payments are in fact not made with an add-on loan. The pure discount method (the only case they present) usually is modified so the borrower can obtain an original principal amount equal to that obtained with an add-on loan. Nominal interest rates (APR's), shown in table 8.4, are substantially overestimated for both add-on and discount methods when there are more than two loan payments each year. The authors could have cleared up some of these mistakes by a fairly brief explanation of the "Rule of 78's" and proceeded to show how the rule is applied for their installment loan examples. In general, more attention to loan cost terminology is needed throughout chapter 8.

The critical comments of this review must be seen in the light of an absolute set of norms. Ideal chapters are easy for finance instructors to demand but extremely difficult to deliver, especially in an original edition. My overall evaluation is that Penson and Lins have presented us with a book which should prove to be functional in several ways: (*a*) as an intermediate level text, (*b*) as a reference source for an introductory course, and (*c*) as a review source for beginning graduate students majoring in agricultural finance.

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Rausser, Gordon C., and Eithan Hochman. *Dynamic Agricultural Systems: Economic Prediction and Control.* New York: Elsevier North-Holland, 1979, 364 pp. (volume 3 in a series of volumes in Dynamic Economics: Theory and Applications).

This is an important book with serious flaws. It is important because of the dynamic and risky features of agricultural systems. The returns from more analyses of the type referred to appear to be great, and relatively few agricultural economists are equipped to utilize these tools. Many would find it useful to have an accessible exposition and clear demonstration of the use of these tools.

Unfortunately, this volume is flawed in both concept and execution. It seems that the authors and editor could not decide whether to produce a textbook, a research monograph, or a collection of prior works of the authors. A successful textbook would require a more careful exposition of the techniques and some practice exercises. A successful research monograph would have more original material and more detailed proofs. A collection of previous works would usually compile a greater volume of works. In execution, fundamental errors of English grammar are sufficiently numerous to be

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In this issue: Proceedings papers from the 1980 AAEA-AEA joint meeting

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Articles

The Effects of Changing Input Costs on Food Prices

R. McFall Lamm and Paul C. Westcott

The relationships between changes in food sector input costs and retail food prices are examined. Results indicate that increases in factor prices pass quickly to consumers, within two quarters for most foods. In addition, rising farm-level prices and substantial increases in nonfarm resource prices appear to explain why food prices rose more rapidly than nonfood prices in the 1970s. The analysis is based on a twenty-equation econometric model of the food-price determination process, specified following Popkin's "stage of processing" approach. Causality and validation test statistics for the model are presented.

Key words: food prices, forecasting model, simultaneous equation system, stage of processing.

During the 1970s, retail food prices increased an average of 8% per year. This was significantly greater than the 6.8% annual rise in nonfood prices and represented a reversal of the pattern in the 1950s and 1960s when food prices increased at a lower rate than nonfood prices. Although money market developments were largely responsible for the rising level of food prices during the 1970s, few satisfactory explanations have been offered concerning why food prices rose faster than nonfood prices.

The purpose of this paper is to consider this issue by examining the relationships between changes in factor prices and changes in retail food prices. A major concern is the impact on consumers of changes in raw foodstuffs prices, as well as the impact on consumers of changes in the cost of other resources used in food processing and distribution. The analysis is based on an extension of Popkin's "stage of processing" model, which provides a general representation of price determination processes. A small, quarterly, econometric model consisting of twenty linear equations serves as a foundation for the study.

The markup model proposed by Popkin requires that prices be written by "stage of processing" as functions of current and lagged resource prices as well as excess demand variables. This approach contrasts with that used for standard markup models and other price determination models (see Gardner, Heien, Maccini, and Phelps, for example) in that there is a greater emphasis on utilizing the appropriate industry price variables than is typically the case. Popkin's principal argument, and the one adopted in this paper, is that there are many theories of price determination, none of which can be demonstrated superior to the others. Consequently, general price equations embodying the central theses of many different theories may serve as empirical approximations.

The Model

It is assumed that retail food prices are determined by the general markup process

$$(1)\quad p_{it} = \phi_i[E_{t-1}(p_{it}); \mathbf{p}_{it}, \ldots, \mathbf{p}_{i,t-n}; \mathbf{r}_t, \ldots, \mathbf{r}_{t-m}] \qquad i = 1, \ldots, I;\ t = 1, \ldots, T,$$

where $E_{t-1}(\ldots)$ is an operator generating the expected value of the operand in period t conditional on information available in $t-1$, $\mathbf{p}_i$ is a vector of the prices of goods which are substitutes or complements for the ith good ($p_i \notin \mathbf{p}_i$), $\mathbf{r}$ is a vector of input prices, and the variables n and m denote maximum lag lengths. In

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general, the signs of the $\partial p_{it}/\partial r_{js}$ $s \leq t$ are expected to be positive—increases in resource prices are passed through to output markets. The signs of $\partial p_{it}/\partial E_{t-1}(p_{it})$ are indeterminant and depend on the nature of market power in the industry and the extent to which consumers are able to substitute for the ith food. Similarly, the signs of $\partial p_{it}/\partial p_{js}$ $s \leq t$ are indeterminant, depending on whether the jth good is a complement or a substitute.

An interesting aspect of equation (1) is its simultaneous structure. Most markup models have excluded the prices of close substitutes and complements, relying instead on various demand pressure variables such as overtime hours and excess capacity in the markets being analyzed. Simultaneity in consumption is an important aspect of food price determination, however. When retail beef prices rise significantly, there is usually a demand pull effect on pork and poultry prices, for example. This is an important part of the food-price-determination causal chain.

Another important feature of the process specified in equation (1) is the nature of the relationship between output and input prices. Different output prices are jointly determined by expectations, current input prices, and lagged output prices. But the causal path between resource prices and output prices is assumed to be unidirectional—resource prices determine output prices. In most manufacturing industries where imperfect competition prevails, this assumption would be acceptable. However, the processing and distributing functions for some foods are carried out in competitive markets. Hence, this assumption may be questionable.[1] Farm-level commodity prices and retail food prices may be determined simultaneously. Alternatively, retail food price changes may cause farm-level price changes if consumer demand variables such as tastes, income, and expectations dominate the retail food price determination process.[2] Consequently, it is necessary to view the assumption that farm-level prices cause retail food prices as a conjectural hypothesis to be tested.

Empirical Implementation and Estimation Results

To estimate the model, equation (1) is assumed linear, with the included variables representing candidates that might appear in structural equations for each of fifteen major BLS food groups considered in the study. Although several processing stages are required to transform raw foodstuffs into finished consumer foods, the farm-to-retail processing and distribution function is viewed essentially as one stage. This is a necesssary simplification, given data limitations and the problem of separating vertically integrated firms by processing stage.

Dependent price variables are expressed as quarterly percent changes, as are all other variables except seasonal dummies and a time trend variable. Retail food prices are represented by the appropriate consumer price indexes (CPIs); wage rates come from the BLS employment and earning series; farm-level prices for foodstuffs come from the "prices received by farmers" series maintained by the U.S. Department of Agriculture (USDA); and imported food prices and prices for other inputs used in food processing and distributing (energy, paper, glass containers) are represented by the appropriate producer price indexes (PPIs). Each series is obtained by averaging the appropriate monthly data. Estimation is based on percent changes from the second quarter of 1968 through the fourth quarter of 1977. In addition, data from the first quarter in 1978 through the last quarter in 1979 are retained for validation purposes.

Each of the fifteen retail food price equations included in the model was developed deductively—the dependent price variable was first selected and the appropriate wages, farm-level prices, and other resource prices were then included. In addition, because of the importance of seasonal effects in the food price determination process (prices are generally lower at harvest, for example), quarterly seasonal dummies were added. Each equation was then estimated using ordinary least squares (OLS). Variables not contributing significantly to explanatory power were deleted from each equation following Theil's (1971) explanatory set reduction strategy. Al-

[1] Parker and Conner indicate that the total social loss due to monopoly in food manufacturing was on the order of \$10–\$12 billion in 1975, while Marion et al. estimate that monopoly overcharges in the food retailing industry may be as high as 6.8% of total food sales in some metropolitan areas. But in many food-manufacturing industries and in numerous urban food markets, 4-firm concentration ratios are less than 0.4—the point typically used to distinguish effective from imperfect competition.

[2] For example, an increase in consumer tastes for a group of foods or a rise in income would lead to an increase in retail food prices. Farm foodstuffs prices would increase as a consequence. In this way, higher retail food prices would "cause" higher farm-level prices.

ternative price expectation formation processes also were evaluated in this way, with a simple first-order autoregressive process generally found to be acceptable. These specification experiments were viewed as necessary steps because the model is not based explicitly on one theory of behavior and because forecasting accuracy is a major design goal.

Although the CPI for food consumed at home is a weighted sum of the fifteen food price indexes included in the study, the estimation of an aggregation equation is necessary to obtain changes in "grocery store" prices from the model. Adding another behavioral equation explaining the determination of changes in away-from-home food prices (at restaurants, cafeterias, and fast food establishments), and adding a second aggregation equation relating changes in the CPI for all food to changes in the CPIs for food consumed at home and away from home, gives estimates of changes in the "all food" CPI. To allow interaction between changes in food sector prices and those in the rest of the economy, two additional equations were added: a Phillips curve relating nonfood price change to changes in unemployment and other variables and an aggregation relation expressing changes in the CPI for all items as a linear combination of changes in the food and nonfood CPIs. The result is a simultaneous model consisting of seventeen behavioral relations and three aggregation equations.[3]

Following preliminary estimation by OLS, the complete model was estimated using three-stage least squares under the assumption that stochastic errors were correlated across equations.[4] Estimation results are presented in table 1. Variable definitions are given in table 2. In general, the statistical fit of the model is excellent—virtually all variables are highly significant, the signs on all input prices are positive, and the estimated coefficients appear to be appropriate in magnitude.

One important result reflected in the estimates is the low order of the lags in the behavioral equations—the maximum lag which appears in any equation is one quarter. Indications are that increases in input prices, changes in expectations, and demand shifts all impact almost immediately on retail food prices. This contrasts with results typically presented for nonfood markup models, which often exhibit complex lag patterns, and is probably a consequence of the perishability of food.

Other characteristics of the model include: (*a*) the limitation of simultaneity, principally to high protein foods—current endogenous variables are included on the right-hand side only for meats, poultry, and fish (and aggregation relations); (*b*) an important role for expectation formation—lagged own prices enter seven behavioral equations; and (*c*) an important role for seasonality—binary seasonal variables are included in eight behavioral equations. These model characteristics derive largely as a consequence of the statistical criteria used in specification.

Causality Tests

An important assumption underlying estimation is that farm-level prices cause retail food prices, implying that farm foodstuffs prices are the appropriate right-hand-side variables. If this is not the case, then the model is invalid because causality is postulated as unidirectional from farm to retail level prices. This assumption is tested explicitly following a procedure suggested by Mehra for implementing Sims' causality test. The necessary steps include (*a*) filtering the retail and farm-level-price time series to remove autocorrelation, and (*b*) regressing each filtered series on the current value, four future values, and eight lagged values of the other series, as well as on seasonal dummies and a time trend. F-tests on each regression are then performed to determine whether the coefficients attached to future values are significantly different from zero. Under the null hypothesis that the dependent variable does not cause the independent variable in each regression, the coefficients of future values will jointly be zero.

Table 3 presents F-statistics of the null hypothesis that farm-level prices do not cause retail food prices, and that retail food prices do not cause farm-level prices. In addition, parameter values for the second order filters used for each price series are also presented. The results imply that in seven out of eleven

[3] The relationship between percent changes in the CPIs for all items, food, and food at home and percent changes in the components making up these aggregates is not an exact identity, although the relationship between the levels of these indexes is exact. This is because the transformation from levels to percent changes is nonlinear.

[4] Predicated values for endogenous variables in the second stage of estimation converged to their actual values, so actual endogenous values were used in the third stage.

Table 1. Three-Stage Least Squares Estimates of Model Parameters

Variable	Estimate[a]
cbf_t	$-1.6 + .27\, fca_t + .32\, fca_{t-1} + .25\, pen_t + 1.32\, wfs_t - .24\, cbf_{t-1} + .15\, cpk_t + .14\, cpy_t - 1.7\, b_{1t} + 1.6\, b_{3t}$
	(0.9) (.03) (.03) (.05) (.41) (.08) (.05) (.04) (0.6) (0.6)
	$- .074\, t.$[b]
	(.017)
cpk_t	$-2.0 + .25\, fho_t + .095\, fhc_{t-1} + .71\, wmp_t + .16\, cpk_{t-1} + .23\, cpy_t + .25\, cbf_t + 2.6\, b_{2t}.$
	(0.5) (.02) (.027) (.24) (.06) (.04) (.08) (0.6)
com_t	$.14 + .049\, fho_{t-1} + .36\, com_{t-1} + .24\, cbf_t + .21\, cpk_t.$
	(.20) (.010) (.05) (.04) (.03)
cpy_t	$-1.8 + .40\, fbr_t + .16\, ftu_t + .72\, wgr_{t-1} + .20\, cpk_t + .29\, cbf_{t-1}.$
	(0.6) (.02) (.03) (.26) (.05) (.07)
cfh_t	$1.5 + .16\, pen_t + .35\, wgr_t - .51\, cn_{t-1} + .12\, com_t + .049\, cpk_{t-1} + .019\, t.$
	(0.3) (.02) (.09) (.12) (.03) (.014) (.006)
ceg_t	$1.6 + .79\, feg_t + 1.30\, wgr_{t-1} - 5.9\, b_{1t} - 4.4\, b_{2t} - 5.5\, b_{3t}.$
	(1.6) (.05) (.71) (1.7) (1.6) (1.6)
cdy_t	$-3.4 + .33\, fmi_t + .25\, fmi_{t-1} + .13\, ppa_t + .94\, wn_{t-1} + 1.07\, wn_t + 2.7\, b_{1t} - 2.2\, b_{3t}.$
	(0.8) (.03) (.02) (.07) (.28) (.29) (0.3) (0.3)
ccb_t	$-2.5 + .11\, fwh_{t-1} + 1.00\, wn_t + .67\, wn_{t-1} + .17\, ppa_{t-1} + .51\, ccb_{t-1}.$
	(0.3) (.01) (.33) (.33) (.09) (.06)
cfo_t	$-2.5 + .14\, fso_{t-1} + .17\, pen_{t-1} + .12\, pgb_t + 1.28\, wn_{t-1} + .42\, cfo_{t-1}.$
	(0.9) (.01) (.06) (.08) (.50) (.05)
css_t	$-1.8 + .16\, psu_t + .17\, psu_{t-1} + .19\, pen_{t-1} + 1.65\, wn_{t-1}.$
	(1.0) (.02) (.01) (.07) (.56)
cop_t	$-1.9 + .051\, pen_{t-1} + 1.11\, wfs_t + .48\, ppa_t + .24\, ppa_{t-1}.$
	(0.3) (.033) (.13) (.09) (.06)
cbe_t	$-2.2 + .12\, pco_t + .21\, pco_{t-1} + .23\, pgb_t + .20\, pen_{t-1} + 1.01\, wfs_t + .28\, cbe_{t-1}.$
	(1.0) (.02) (.03) (.09) (.07) (.44) (.07)
cfr_t	$-2.0 + .16\, ffr_t + 1.05\, wgr_t + 9.3\, b_{1t} + 5.8\, b_{2t} - 8.8\, b_{3t}.$
	(1.1) (.03) (.38) (1.0) (1.0) (0.9)
cvg_t	$5.0 + .40\, fvg_t + .21\, fvg_{t-1} - 7.1\, b_{2t} - 10\, b_{3t}.$
	(1.3) (.06) (.06) (2.0) (2)
cfv_t	$-1.5 + .36\, pen_t + .69\, wfs_t + .25\, cfv_{t-1} - 1.0\, b_{3t}.$
	(0.6) (.05) (.31) (.09) (0.5)
ch_t	$.13\, cbf_t + .058\, cpk_t + .077\, com_t + .057\, cpy_t + .016\, cfh_t + .033\, ceg_t + .13\, cdy_t + .12\, ccb_t + .019\, cfo_t$
	(.009) (.007) (.019) (.006) (.017) (.002) (.025) (.019) (.010)
	$+ .057\, css_t + .003\, cop_t + .079\, cbe_t + .039\, cfr_t + .055\, cvg_t + .064\, cfv_t.$
	(.009) (.019) (.005) (.003) (.003) (.017)
ca_t	$.47 + .11\, wed_{t-1} + .27\, ch_{t-1} + .38\, ca_{t-1}.$
	(.15) (.04) (.03) (.07)
cf_t	$.78\, ch_t + .22\, ca_t.$
	(.00) (.01)
cn_t	$-.06 + .061\, pen_t + .019\, u_t - .015\, u_{t-1} + .61\, cn_{t-1} + .77\, b_{1t} + .31\, b_{2t} + .60\, b_{3t}.$
	(.12) (.009) (.005) (.005) (.07) (.10) (.09) (.09)
c_t	$.23\, cf_t + .76\, cn_t.$
	(.00) (.01)

[a] Estimates are based on quarterly data from 1968-2 through 1977-4.
[b] Standard errors are presented in parentheses.

cases the hypothesis that farm foodstuffs prices do not cause retail food prices can be rejected with 99% confidence—the critical F-value with (4, 15) degrees of freedom is 4.89. In contrast, in only one out of eleven cases can the hypothesis that retail prices do not cause farm foodstuffs prices be rejected. The basic implication is that causality is unidirectional from farm to retail prices for all foods considered in the study, except between the cereals and bakery products CPI and wheat prices (which are determined to be jointly causal) and between retail and farm-level prices for fresh fruits and vegetables (for which no causal relationship is found). This finding is generally consistent with Heien's results using monthly data and it supports the use of a markup pricing model representation of the food price determination process.

Validation

Any econometric model that is a valid representation of the system it is designed to emulate must be able to explain behavior over the

Table 2. Symbols and Definitions of Variables Used in the Model

Endogenous Variables		Exogenous Variables	
Consumer price indexes		*Prices received by farmers*	
cbf	Beef and veal	*fca*	Cattle
cpk	Pork	*fho*	Hogs
com	Other meats	*fbr*	Broilers
cpy	Poultry	*ftu*	Turkeys
cfh	Fish	*feg*	Eggs
ceg	Eggs	*fmi*	Milk
cdy	Dairy products	*fwh*	Wheat
ccb	Cereals and bakery products	*ffr*	Fruit
cfo	Fats and oils	*fvg*	Commercial vegetables
css	Sugar and sweets	*Producer price indexes*	
cop	Other prepared foods	*psu*	Raw cane sugar
cbe	Nonalcoholic beverages	*pco*	Green coffee
cfr	Fresh fruits	*pgb*	Glass bottles
cvg	Fresh vegetables	*ppa*	Paper
cfv	Processed fruits and vegetables	*pen*	Energy (fuels and related products, and power)
ch	Food at home	*Wage rates*	
ca	Food away from home	*wmp*	Meat packing plants
cf	Food	*wgr*	Grocery stores
cn	Nonfood	*wfs*	Food stores
c	All items	*wed*	Eating and drinking establishments
		wn	Total private nonfood establishments
		Others	
		fso	Soybean oil price at Decatur
		u	Unemployment rate
		t	Time trend
		b_i	Binary variable equal to one for the $(i + 1)$th quarter, zero otherwise

estimation period and over a data set not included in estimation. The typical approach in time-series analysis is to reserve the most recent data available historically for a "beyond sample" validation—usually two to three years for a quarterly model—while using the bulk of the information set for estimation and a "within sample" validation. Simulated deterministic time paths for endogenous variables are generated using the model and compared with actual system time paths for consistency. This is the approach followed here.

Table 4 presents summary validation statistics for a comparison of simulated deterministic time paths with actual system paths. The simulated time paths are produced by using actual lagged endogenous values in the first period solution, and then using generated lagged endogenous values in successive solutions, allowing a complete dynamic response. Actual exogenous values are used for all solutions. The "within sample" validation covers the estimation period from the second quarter of 1968 to the fourth quarter of 1977, while the "beyond sample" validation covers the eight quarters of 1978 and 1979. Mean absolute percentage errors (MAE) and Theil (1966) inequality coefficients are presented for each CPI category.

The results indicate that the model performs extremely well, both for the "within sample" validation and the "beyond sample" validation. The MAEs are small and all inequality coefficients are substantially less than unity for the within sample validation. The MAEs and inequality coefficients for the beyond sample validation indicate a less satisfying performance, but nonetheless are supportive. The largest MAEs occur for fresh fruit and fresh vegetables—foods particularly sensitive to labor disputes and transportation problems. The largest inequality coefficients occur for sugar and sweets, nonalcoholic beverages, and processed fruits and vegetables—markets characterized by a high degree of nonprice competition. The model does not include an advertising cost measure that might improve the performance of the equations for these foods.

Table 5 presents quarterly forecasts for the beyond sample validation. Predicted changes in the three major food CPIs considered in the study are given, based on actual exogenous data and generated endogenous data. These results illustrate on a quarter-by-quarter basis how well the model performs, over a period not used in estimation, in the prediction of three food price aggregates which are of most interest to policy makers.[5]

An even more stringent validation is possible if the exogenous values of the model are also forecast. This represents a complete test of the model as a forecasting system, and allows a direct comparison with food price forecasts generated by other models. Two procedures are used to predict the values of exogenous variables in this study: (*a*) all exogenous values are forecast using autoregressions of

[5] The validation statistics presented here are superior to similar data for a food price-forecasting model developed by Barr and Gale.

Table 3. *F*-Statistics and Filters for Tests of Causality Hypotheses

		F-Statistic for		Filter for	
Retail Price	Farm-Level Price	Farm-Level on Retail Price Regression	Retail on Farm-Level Price Regression	Retail Price	Farm-Level Price
cbf	*fca*	5.17	3.42	−.25	−.75
cpk	*fho*	3.39	2.14	−.30	−.45
cpy	*fbr*	6.10	4.54	−.25	−.25
ceg	*feg*	7.95	3.38	−.50	−.50
cdy	*fmi*	7.25	.68	.00	.00
ccb	*fwh*	30.61	4.94	.50	.15
cop	*fso*	9.14	1.55	.25	.10
css	*psu*	17.66	.67	.00	.25
cbe	*pco*	3.37	.99	.50	.00
cfr	*ffr*	1.11	.23	.25	−.50
cvg	*fvg*	.96	.57	.00	−.33

current exogenous variables on lagged exogenous variables (twelve quarters of lags for cattle, hog, wheat, and soybean oil prices, and four quarters of lags for all other exogenous variables), a time trend, and seasonal dummies; and (*b*) farm-level prices are forecast using patterns of change implied by the appropriate futures market prices, with other exogenous variables forecast using autoregression. In this latter procedure, futures prices from the last business day in December are used to obtain quarterly forecasts for the following year by interpolation and averaging monthly contract values. Futures prices for cattle, hogs, broilers, and eggs are from contracts traded on the Chicago Mercantile Exchange; futures prices for wheat and soybean oil are from the Chicago Board of Trade; and futures prices for coffee and sugar are obtained from the New York Coffee and Sugar Exchange.

Table 4. Selected Statistics for Within and Beyond Sample Validations of the Model

	Within Sample Period[a]		Beyond Sample Period	
Consumer Price Index	Mean Absolute Percentage Error	Theil Inequality Coefficient	Mean Absolute Percentage Error	Theil Inequality Coefficient
Beef and veal	0.9	.29	2.7	.42
Pork	1.4	.25	1.8	.56
Other meats	0.9	.33	2.1	.52
Poultry	1.6	.31	2.2	.57
Fish	0.6	.28	1.3	.63
Eggs	2.8	.28	2.2	.45
Dairy products	0.6	.34	0.8	.33
Cereals and bakery products	0.9	.37	1.4	.59
Fats and oils	1.3	.33	1.3	.73
Sugar and sweets	1.2	.24	2.0	1.04
Other prepared foods	0.5	.25	0.7	.39
Nonalcoholic beverages	1.5	.37	2.5	2.01
Fresh fruits	1.7	.29	2.9	.30
Fresh vegetables	3.6	.53	3.9	.49
Processed fruits and vegetables	1.1	.49	2.1	1.11
Food at home	0.4	.22	0.4	.15
Food away from home	0.3	.22	0.5	.26
Food	0.4	.20	0.3	.12
Nonfood	0.3	.18	1.0	.39
All items	0.2	.16	0.8	.32

[a] The "within sample" validation covers the period from 1963-2 through 1977-4, while the "beyond sample" validation is carried out over the period 1978-1 through 1979-4.

Table 5. Quarterly Forecasts of Changes in Selected Consumer Price Indexes Using Actual Exogenous Data, 1978-1 through 1979-4

	Food at Home		Food Away from Home		Food	
Quarter	Actual	Predicted	Actual	Predicted	Actual	Predicted
	(%)					
1978-1	3.7	3.7	2.4	1.2	3.3	3.2
2	5.1	4.8	2.7	2.5	4.3	4.3
3	2.1	2.6	2.6	2.7	2.3	2.6
4	1.0	1.1	2.0	2.3	1.3	1.3
1979-1	4.8	5.0	3.2	1.9	4.4	4.3
2	2.7	2.1	3.2	2.9	2.9	2.3
3	0.7	0.6	2.3	2.1	1.2	0.9
4	0.9	1.9	2.1	1.5	1.2	1.8

Table 6 presents actual changes in the CPI for food, forecast changes in the CPI for food based on the two procedures just described, and USDA Outlook Conference forecasts of the CPI for food over the eight quarters in 1978 and 1979.[6] Indications are again that the model performs well, particularly with respect to the USDA forecasts—the mean absolute error for the model using either exogenous variable forecasting procedure is about half the error in the USDA forecasts.

Implications

Proceeding under the assumption that the model is well specified and a valid representation, as the evidence would suggest, it is important to review the full implications of the structural equations presented in table 1. In this regard, since the model is linear, it becomes a simple matter to derive the reduced form of the model from the structure, and to generate the appropriate dynamic system multipliers from the reduced form. This allows a more complete synthesis of the information contained in the structural parameters, provides yet another means for validating the model, and serves to delineate some of the model's weaknesses.

Table 7 gives Goldberger impact and total multipliers for ten selected exogenous variables—three farm-level prices, three producer price indexes, and four wage rates—with respect to all endogenous variables except the nonfood CPI. Each impact multiplier gives the effect of a 1.0% increase in the exogenous

[6] The USDA Outlook Conference is generally held each November to brief farm organizations, the press, food processors, and food distributors on forecasts for the coming year.

Table 6. Model Forecasts of Changes in the Consumer Price Index for Food, 1978-1 through 1979-4

		Forecast Change with Exogenous Variables Predicted by		
Quarter	Actual Change	Auto-regression	Auto-regression and Futures Prices	USDA Outlook Conference Forecast
	(%)			
1978-1	3.3	2.9	2.9	0.2
2	4.3	2.0	2.6	1.4
3	2.3	1.9	2.0	0.7
4	1.3	1.3	0.8	0.3
1979-1	4.4	3.3	3.3	1.7
2	2.9	2.2	2.5	1.7
3	1.2	2.3	2.2	1.8
4	1.2	1.2	1.1	0.7

Note: Model forecasts for 1978 are based on the coefficients presented in table 1; 1979 forecasts are based on a reestimated version of the model using data from 1968-2 through 1978-4.

Table 7. Selected Impact and Total Multipliers for the Model

Consumer Price Index for	Farm-Level Prices for						Producer Prices for						Wage Rates at							
	Cattle		Hogs		Broilers		Energy		Paper		Glass Bottles		Meat Packing Plants		Food and Grocery Stores		Eating and Drinking Establishments		Nonagri-cultural Establishments	
	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total
Beef and veal	.285	.521	.048	.067	.076	.067	.261	.220	—	—	—	—	.139	.139	1.383	1.287	—	—	—	—
Pork	.074	.203	.274	.457	.113	.138	.068	.086	—	—	—	—	.784	.949	.357	.705	—	—	—	—
Other meats	.082	.257	.068	.248	.041	.069	.075	.109	—	—	—	—	.194	.357	.209	.701	—	—	—	—
Poultry	.015	.190	.054	.110	.418	.442	.013	.080		—	—	—	.155	.228	.071	1.227	—	—	—	—
Fish	.010	.041	.009	.053	.003	.015	.165	.093	—	—	—	—	.024	.090	.397	.468	—		—	—
Eggs	—	—	—	—	—	—	—	—	—	—	—		—	—	—	1.300	—	—	—	—
Dairy products	—	—	—	—	—	—	—	—	.127	.127	—	—	—	—	—	—	—	—	1.070	2.000
Cereals and bakery products	—	—	—	—	—	—		—	—	.346	—	—	—	—	—	—	—	—	1.003	3.385
Fats and oils			—	—	—	—	—	.285	—	—	.122	.209	—	—	—	—	—	—	—	2.206
Sugar and sweets	—	—	—	—	—	—	—	.189	—	—	—	—	—	—	—		—	—	—	1.649
Other prepared foods	—	—	—	—	—	—	—	.051	.482	.726	—	—	—	—	1.108	1.108	—	—	—	—
Nonalcoholic beverages	—	—	—	—	—	—	—	.278	—	—	.229	.319	—	—	1.005	1.402	—	—	—	—
Fresh fruits	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.049	1.049	—	—	—	—
Fresh vegetables	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Processed fruits and vegetables	—	—	—	—	—	—	.362	.480	—	—	—	—	—	—	.690	.917	—	—	—	—
Food at home	.048	.110	.031	.061	.044	.047	.070	.117	.018	.062	.020	.029	.088	.115	.407	.594	—	—	.266	.821
Food away from home	—	.047	—	.026	—	.020	—	.050	—	.026	—	.012	—	.049	—	.253	—	.170	—	.350
Food	.038	.096	.024	.054	.034	.042	.055	.102	.014	.054	.016	.025	.069	.100	.318	.520	—	.037	.209	.720
All items	.009	.023	.006	.013	.008	.010	.059	.142	.003	.013	.004	.006	.016	.024	.075	.122	—	.009	.049	.168

variable on the appropriate endogenous variable in the current period, while the total multipliers represent the effect of a 1.0% increase when all lagged adjustments are considered. Each of the multipliers is generally of the expected sign and magnitude, with the most important summary information contained in the multipliers on the food at home CPI, the food CPI, and the total CPI.

On the basis of the impact multipliers, food-at-home prices are affected most by higher wages at food and grocery stores. A 1.0% increase in retail wages in the current quarter leads to an immediate increase in food-at-home prices of more than 0.4% and a rise in total food prices of slightly more than 0.3%. The same increase also pushes up the total CPI by .075%—the largest impact of any food sector input price on the total CPI. Increases in meat-packing plant wages and in nonagricultural establishment wages (a proxy for food-processing wages) also have large immediate impacts. These findings are consistent with USDA data attributing about one-third of the cost of food to labor.

Changes in farm-level prices for cattle, hogs, and broilers also have significant immediate impacts on retail food prices and the CPI for all items. A 1.0% rise in cattle prices causes a .285% increase in the CPI for beef and veal, a .038% rise in the CPI for food, and a .009% increase in the CPI for all items. Upward movements in hog and broiler prices have similar impacts, although of lesser magnitudes. Changes in cattle, hog, and broiler prices also have a positive impact on the CPIs for other meats and fish. There is no immediate impact on restaurant and cafeteria prices from current increases in farm-level meat prices, largely because of contracting by chains and delays in the menu pricing process. The interim multipliers for these variables in the two subsequent quarters are substantial, however.[7]

The impact of increases in other resource prices is dominated by energy. A 1.0% rise in the PPI for energy, which reflects both power and transportation cost increases, leads to a .261% increase in beef prices, a .068% increase in pork prices, and a .075% rise in prices for other meats. The same increase also pushes up fish prices .165%, and processed fruits and vegetable prices by .362%. The immediate impact of a 1.0% increase in energy prices on the CPI for food is a .055% increase. After one quarter, the interim multipliers for a 1.0% increase in energy prices are large for some foods because of the lag before higher prices are passed through to retail. A 1.0% increase in energy prices this quarter leads to a .032% rise in the CPI for food next quarter, and a .010% increase two quarters ahead. Three quarters ahead and beyond, the impact of a 1.0% increase in energy prices in the present quarter is virtually zero.

The small size of the energy interim multipliers beyond two quarters ahead is a general characteristic of all interim multipliers in the model. Changes in input prices for the food industry have their greatest effect on retail food prices in the current quarter and one quarter ahead, with a smaller impact two quarters ahead and insignificant impacts three and more quarters ahead. This multiplier pattern serves to distinguish the food sector from other sectors in the economy that generally exhibit more complex lag structures and larger interim multipliers in later quarters. This finding has important implications with respect to public policy implementation at the farm level. Indications are that policies that affect farm-level foodstuffs prices have an effect on retail food prices almost immediately. Similarly, changes in wages and nonlabor resource prices are quickly passed through to the retail level.

Virtually all total multipliers are fairly small multiples of the impact multipliers, additional evidence of the short time lag before increasing resource prices are passed through to consumers. The magnitudes of the total multipliers further illustrate the importance of labor, energy, and packaging materials as important determinants of retail food prices. One implication of this result is that the role of changing input prices is a crucial aspect of the recent food price inflation. This role is often overlooked in the public dialogue on the causes of higher retail food prices.

Conclusion

This paper has reviewed the nature of the relationships between changes in food sector input prices and retail food prices based on a small econometric model. The model is a generalization of Popkin's "stage of processing" approach and includes all of the major inputs used in domestic food production. The basic findings are that (*a*) the lag structure of the food industry is relatively simple, with most of

[7] Interim multipliers are not presented in the text. They are available from the authors in a statistical appendix which also includes a listing of the data used in the analysis.

the impact of changing resource prices being passed through to the retail level within two quarters; and (*b*) changes in nonfarm resource prices are important, even dominant, in the food price determination process. With respect to the lag structure, the results presented here confirm findings by Barr and Gale indicating a fairly simple lag structure for the food industry. In addition, the finding that changes in farm-level prices are passed through quickly to retail, especially for fresh foods, confirms results obtained by Heien and Lamm using monthly models. With respect to nonfarm resource prices, the model is consistent with USDA estimates of the relative contributions of various inputs to retail food price determination.

The identification of the most significant determinants of retail food prices provides a response to the question of why food prices increased more rapidly than nonfood prices in the 1970s. From 1970 to 1979, the price of farm commodities used in food rose 9.1% per year; all wage rates represented in the model increased more than 7.1%; and the energy PPI increased 15.8%. These increases, when passed through to consumers, led to the 8.0% annual rise in the CPI for food over the period. This contrasts significantly with the 6.8% increase in nonfood prices. On this basis, it is apparent that not only were rising farm-level prices an important cause of higher relative food prices in the 1970s, but increases in nonfarm resource prices were important as well.

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Commodity Price Forecasting with Large-Scale Econometric Models and the Futures Market

Richard E. Just and Gordon C. Rausser

This paper compares the accuracy of major commercial price forecasts for corn, wheat, soybeans, soybean oil, soybean meal, cotton, live cattle, and hogs. The price-forecasting information in futures prices is evaluated by comparison. The results among commercial forecasters are mixed, but futures prices perform relatively better on average although not universally so. These results have important implications for operational risk management.

Key words: futures prices, price forecasting.

Commercial forecasts of spot prices in agricultural commodity markets have been available since 1976. These forecasts are produced quarterly, refer to specific cash markets, and cover a number of commodities. The firms that generate and sell these forecasts, largely to agribusiness companies, include Chase Econometrics, Doanes Agricultural Service, Data Resources, Inc. (DRI), and Wharton Econometric Forecasting Associates. The U.S. Department of Agriculture (USDA) also develops such forecasts for internal use. Most of these forecasts are based upon large-scale, U.S. agricultural sector models which specify formal links among individual commodities. The purpose of this paper is to compare and evaluate the price-forecasting experience and accuracy of the commercial vendors that produce point forecasts.

The questions addressed include the following. What is the comparative and absolute accuracy of the various vendors? Does the comparative accuracy of different models depend upon the forecast horizon—for example, is one model more accurate for, say, a one-quarter forecast and another more accurate for a two-quarter-or-longer term forecast? Is the relative and absolute forecast accuracy commodity dependent? What types of errors tend to be made by various firms, and how do these relate to a user's selection of forecast to purchase?

The commodities examined include corn, wheat, soybeans, soybean oil, soybean meal, cotton, live cattle, and hogs. One-quarter through four-quarter forecast horizons are investigated. Accuracy is evaluated by computing two statistical measures of equality—root mean squared error and root mean squared percentage error—of the forecasts of average quarterly cash market prices over the period 1976–1978.

The price-forecasting information contained in futures market prices is also evaluated. Some of the literature on futures markets questions the quality of futures prices as forecasts (Working, Tomek and Gray, Labys and Granger). Working (p. 49) states that "it is not true that futures prices afford forecasts of price change in the sense in which one speaks of the price forecasts of a market analyst" but, however, "neither is it true that futures prices provide no sort of forecast of price change." In addition, much of the recent conceptual work on futures markets views futures prices as rationally based expectations (Danthine; Peck;

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Feder, Just, Schmitz; Holthausen; Turnovsky; Anderson and Danthine). Some recent empirical evidence also strongly suggests that futures prices play an important role in the formation of producer price expectations (Peck, Gardner).

In an earlier paper (Rausser and Just), a simple analogy was established between forecasting prices from futures markets and forecasting prices with econometric models. Especially in the case of futures markets, the "aggregate market participant processes" must perform much the same role as an econometric model. Participants must form expectations or forecasts of important exogenous influences—e.g., planning intentions, yields, consumption, export demand, etc.—and transmit this information into a futures price. In addition to random noise, errors can be made in formulating forecasts of the exogenous information or in the transmission of this information into an observed futures price. In the latter context, errors in futures markets arise from uninformed market participants, risk aversion, irrational market participants, imperfect capital markets, and alternative transaction and information costs. These errors in econometric models arise from omitted variables, inappropriate functional forms, measurement errors, aggregation, and the like. With this analogy in mind, futures markets can serve as a basis of comparison for price-forecasting errors emanating from econometric models. Potentially, it is possible for the large-scale econometric models examined in this paper to outperform futures market prices as price forecasters.

In the above setting, this paper addresses the question of whether futures markets are more or less accurate than the large-scale, econometrically based forecasts. The response to this question has some direct implications for future conceptual work as well as operational risk management frameworks of companies that currently purchase econometric forecasts. These implications hold regardless of whether futures market prices are used by commercial vendors to alter their econometric price forecasts (in an ad hoc fashion) or whether traders employ the econometric model price forecasts in determining their positions in futures markets.

The Commercial Forecasts

All four commercial firms considered in this study began making commercial point forecasts of agricultural prices during the latter half of 1976. The frequency and horizon of the respective forecasts thereafter are indicated in table 1 for the eight major agricultural commodities examined by our analysis. In each case, firms made forecasts on a somewhat irregular basis initially but then settled down to a regular pattern in 1977. Since April 1977, DRI's forecasts have been monthly and cover forecast horizons from one to eight quarters. Since June 1977 (October 1977, for soybean oil and meal), Chase has made forecasts with one to eight-quarter horizons on a bimonthly basis. Wharton has forecasted from one to six quarters ahead nearly every month since April 1977. Doanes has made forecasts less frequently (on a quarterly basis) for six of the eight commodities and has forecasted with a horizon of only two, three, or four quarters. The USDA also has been operating on a quarterly basis throughout this period with forecast horizons of one, two, or three quarters.

The Futures Market Price As a Standard of Comparison

For some commodities, several futures markets exist, while for others only a single futures market exists. Since our focus does not address a comparison of futures markets, we narrow the alternative price forecast possibilities by using the Chicago Board of Trade prices for wheat, corn, soybeans, soybean meal, and soybean oil; the New York Cotton Exchange for cotton; and the Chicago Mercantile Exchange for hogs and live cattle.

Given the specified markets and the desire to generate price forecasts, an issue arises as to the appropriate filter of futures market prices to use as a predictor of spot price for the contract month. One approach to this problem is to solve for an optimal filter of futures market prices in current months in predicting spot prices in contract months. The approach taken here, however, is more intuitive and is designed to serve as a standard of comparison with commercial forecasts for which easy access is available. Moreover, to make the comparison fair for the econometric forecasters, the futures market price forecaster should be constructed from information available at about the same time of the month as used by the econometric firms. Most econometric firms collect information about the second week of the month for formulation of forecasts produced near the end of the month. Thus, for

Table 1. Forecast Frequency and Horizon of Major Commercial Econometric Forecasting Firms, July 1976–December 1978

Date of Forecast	Wheat, Corn, Cotton, and Soybeans: Chase	Doanes	DRI[a]	Wharton	USDA[b]	Soybean Oil and Meal: Chase	Doanes	DRI[a]	Wharton	USDA[b]	Hogs and Live Cattle: Chase	Doanes	DRI[a]	Wharton	USDA[b]
	(quarters)														
1976															
July	[c]				1			8		1		3	8		1
August		3	8								7				
September	7										6				
October	6				2					2		2	8		2
November		3	8					8			7			8	
December	7			8					8						
1977															
January			7 (8)	(6)				(8)	(6)				(8)	(6)	
February	7 (8)	3	8	7	2 (3)	(8)		8	7	2	7 (8)	3	8	7	1 (3)
March			(8)	(7)				(8)	(7)				(8)	(7)	
April	6 (8)	4	8	6		(8)		8	6		6 (8)	2	8	6	
May			8	6	3			8	6	3			8	6	2 (3)
June	8		8	6		(8)		8	6		8		8	6	
July			8	6 (5)				8	6 (5)				8	6 (5)	
August	8	4	8	(5)	3[d]	(8)		8	(5)	3	8	3	8	(5)	2 (3)
September			8	6 (0)				8	6 (5)				8	6 (0)	
October	8		8	7		8		8	7 (0)		8		8	7	
November		4	8	(7)	3			8	(7)	1 (3)		2	8	(7)	3
December	8		8	7		8		8	7 (8)		8		8	7 (8)	

Note: Figures in parentheses give 1978 information where it differs from 1977. Where figures appear only in parentheses, no forecast was made in 1977.

[a] Reports a forecast also for cotton price made in April 1976, but this forecast was excluded from the analysis because other firms were not operating in comparable time periods.

[b] Note that the USDA does not forecast cotton price.

[c] Blanks indicate no forecasts were made.

[d] Wheat price was forecasted only two quarters ahead by USDA in August 1977.

the purposes of this paper, we selected as the forecast the average of daily futures market closing prices for the second week of the month. This information is readily available to every decision maker; yet, it does not embody more exogenous information than is supposedly available to the econometric firms. It should be kept in mind, however, that decision makers actually may have access to better information by using futures prices generated later in the month when econometric forecasts actually become available.

Due to the quarterly temporal dimension of the econometric forecasts, a further issue arises as to which contract month for a futures market should be used to represent the forecast horizon. That is, should an econometric forecast for live cattle price in the second quarter of, say, 1980 be compared with the corresponding April or June futures contract price? In some quarters, only one contract exists so no choice is available. In other quarters, however, two or three contracts may be applicable. For the purposes of this study, the midmonth in each quarter is used when available. If a contract does not exist for the midmonth, then the contract for the latter month is used since the prices of these contracts would tend to use more of the information that would affect average quarterly spot market price than the first-month contract. Of course, the first-month contract is used if no other contract exists in the quarter. The futures contracts used are as follows. May is used for the first quarter except for livestock, where February is used. For the second quarter, June is used for livestock and May for all other commodities. For the third quarter, August is used for livestock and soybean derivatives; July for cotton; and September for all others. Finally, for the fourth quarter, November is used for soybeans and December for all others.

The Basis of Comparison

Two sets of comparisons were examined. Due to space limitations, only the first set of comparisons based on the best forecast available from each source by month for the period from December 1976 through December 1978 will be reported. The forecasts prior to December 1975 are excluded from the analysis because not all four firms began forecasting on a commercial basis until that time. The use of the term, "best available" forecast, implies that each firm's forecast in each month is taken to be its latest published forecast. For example, if Doanes makes a forecast in April 1977 and does not make another forecast until August 1977, then the April forecast is used as Doanes' best available forecast in the months of May, June, and July. For customers who need price forecasts on a regular basis for decision-making purposes, it seems that this type of comparison is more meaningful than simply comparing the forecasts only over the set of months in which they actually are made. Admittedly, however, this comparison favors DRI, which revises its forecasts monthly, relative to Doanes, which revises its forecasts only quarterly.

To determine the extent of this bias and to develop more information about the actual forecasting ability of each firm, as opposed to the futures market, a second set of comparisons also was constructed using only those months in which the major commercial econometric firms (excluding Doanes and USDA) actually revised their forecasts. To develop strictly fair comparisons for Doanes and USDA, additional pairwise comparisons were made between DRI and Doanes and between DRI and USDA using only those months in which both made new forecasts. These results are available on request but are too lengthy to present here.

The comparisons employ two statistical measures of quality—root mean squared error and root mean squared percentage error. Due to practical limitations on computation and the desire to simplify the reporting of results, other measures of quality are not investigated here. Moreover, other types of measures—such as mean absolute deviation and Theil U coefficients—generally lead to the same rankings of forecasts for the forecasting problem considered here (St. George et al.).

The econometric firms do not all forecast the same actual price series.[1] Thus, problems

[1] The price series forecasted by the econometric firms considered in this study are as follows: wheat—Chase and Wharton, No. 1 Hard Red Winter wheat, Kansas City ($ per bu.); Doanes, average price received by farmers, United States ($ per bu.); DRI, average of Kansas City, Minneapolis, Portland, and St. Louis prices ($ per bu.); corn—Chase, DRI, and Wharton, No. 2 Yellow corn, Chicago ($ per bu.); Doanes, average price received by farmers, United States ($ per bu.); cotton—Chase, Doanes, and Wharton, average price received by farmers, United States (¢ per lb.); DRI, upland cotton lint price, USDA (¢ per lb.); soybeans—Chase, DRI, and Wharton, No. 1 Yellow soybean price, Chicago ($ per bu.); Doanes, average price received by farmers, United States ($ per bu.); soybean meal—Chase, DRI, and Wharton, bulk, 44% protein price, Decatur ($ per ton); soybean oil—Chase, DRI, and Wharton, crude tank FOB price, Decatur (¢ per

arise regarding comparability due to transportation costs and other factors which cause a divergence of prices in different markets. Also, in using futures market prices as forecasts of spot market prices, one must consider delivery costs. To account for the effect of these factors in the commercial forecasts, each econometric forecast is compared to the actual respective price being forecasted. In order to avoid unduly favoring futures market prices as forecasts, the futures prices are considered as forecasts of the spot prices predicted by most of the econometric firms.[2] As a comparison of futures prices with other spot prices has revealed, these spot prices also appear to be the ones most closely related to the futures market near the time of delivery.

The Comparison of Forecasts

The statistics discussed above are reported in table 2 for the eight respective commodities. (Note that the units reported in table 3 are based upon the measurements defined in fn. 1) An examination of these results reveals some interesting quantitative relationships among alternative forecasters. For example, the variation in root mean squared errors and percentage errors among econometric forecasters is fairly large for given forecasting horizons for wheat, corn, and soybean meal, with differences in root mean-squared percentage error ranging up to over 10%. On the other hand, for cattle—and to a lesser extent cotton, soybeans, and soybean oil—all econometric firms maintain similar magnitudes of error.

Generally, Chase forecasts perform better for wheat and live cattle, Wharton or DRI for corn, Doanes for cotton, and DRI for hogs; but there is no clear dominance of one forecaster over another in most cases when all horizons are considered. Generally, one would expect short horizon forecasts to be more accurate than long horizon forecasts. Forecast error, indeed, tends to increase with forecast horizon for wheat, hogs, cattle, and most soybean derivative forecasts. On the other hand, the forecasts for soybean price seem to be more accurate for longer horizons than for short horizons. This observation may be due to an unusual market trend over the particular period of this study, but it could also be due to the relatively volatile nature of the soybean market. For example, the soybean futures market generally is thought to be a more active and fluctuating market, which makes it relatively attractive to speculators. For this reason, phenomena unrelated to the cash market may play a greater role in short-run trading and price fluctuations, so that the more predictable market movements only tend to occur over a longer time horizon. Indeed, comparing across commodity markets on the basis of root mean-squared percentage errors, the soybean market seems to be much less predictable in the short run than other commodity markets (with the possible exception of soybean derivative markets). The corn and wheat markets, which are generally thought to be much less active and more stable, are more predictable over all horizons (in a mean forecast sense) than the other commodities.

Econometric Forecasting versus Futures Markets

One objective of this paper is to examine the performance of various econometric models using the futures market prices as a standard of comparison. To develop some summary information in this respect, rankings of the five econometric against futures forecasts are given in table 3. These results reveal that no one model performs consistently better over all commodities. This variation in performance may be due to a randomness in characteristics *vis-à-vis* important market phenomena in 1977 and 1978; however, using nonparametric test statistics, many of the results are significant (table 3).[3]

Table 3 reveals the following significant results for performance of the commercial ven-

lb.); hogs—Chase, Doanes, DRI, and Wharton, 7-market average price, barrows and gilts ($ per cwt.); and live cattle—Chase, Doanes, DRI, and Wharton, choice 1,100–1,300 pounds slaughter steer price, Omaha ($ per cwt.). The sources for these data series are various issues of the following publications of the U.S. Economics, Statistics, and Cooperative Service: *Wheat Situation, Feed Situation, Livestock and Meat Situation, Fats and Oils Situation*, and *Cotton and Wool Situation*.

[2] Note that delivery costs are reflected in the basis, i.e., the difference between the futures and the spot price for a specific location. Our analysis assumes that the basis due to commissions, capital costs, risk, and the like is approximately constant (at least over the two-year period of this study) in either an additive or multiplicative sense. Thus, the price forecasts are analyzed only in terms of their deviations from longer-term average levels in either an absolute or percentage sense.

[3] The nonparametric tests assume independence of ranks over forecast horizons. Because the forecasts over various horizons are made under the same (possibly erroneous) model specifications, one must bear in mind the possibility of correlated ranks in which case the test statistics are biased toward significance.

Table 2. Comparison of Best Monthly Forecasts Available, December 1976 through December 1978

	Forecast horizon (quarters)											
	1			2			3			4		
Forecast	R^a	P^b	N^c	R^a	P^b	N^c	R^a	P^b	N^c	R^a	P^b	N^c
Wheat ($ per bu.)												
Chase	0.29	10.9	25	0.35	11.9	22	0.41	12.7	19	0.51	15.3	16
Doanes	0.33	13.1	25	0.41	15.7	22	0.45	16.1	18	0.61	20.8	7
DRI	0.64	18.7	25	0.8[illegible]	22.7	22	0.95	25.9	19	1.10	29.4	16
Wharton	0.28	9.8	25	0.38	12.8	22	0.46	14.4	19	0.61	18.5	16
USDA	0.48	20.2	8	0.52	19.0	7	0.55	18.8	4	[d]		
Futures[e]	0.28	10.3	25	0.36	13.1	22	0.39	12.8	19	0.57	18.0	3
Corn ($ per bu.)												
Chase	0.28	13.7	25	0.35	18.0	22	0.32	15.5	19	0.26	11.8	16
Doanes	0.35	19.3	25	0.40	22.4	22	0.32	16.9	18	0.17	8.2	7
DRI	0.25	12.0	25	0.33	16.0	22	0.31	14.3	19	0.15	6.4	16
Wharton	0.24	11.8	25	0.30	14.3	22	0.25	12.2	19	0.25	11.3	16
USDA	0.39	21.5	[illegible]	0.42	22.1	7	0.24	11.5	5			
Futures[f]	0.28	13.7	25	0.40	19.9	22	0.40	18.8	19	0.05	2.2	3
Soybeans ($ per bu.)												
Chase	1.62	25.5	25	1.22	18.0	22	1.17	17.2	19	1.33	19.1	16
Doanes	1.39	21.2	25	1.14	17.3	22	1.18	18.3	18	1.08	17.0	7
DRI	1.43	22.3	25	1.41	21.5	22	1.14	17.5	19	1.19	17.4	16
Wharton	1.51	23.2	25	1.50	23.9	22	1.47	22.7	19	1.37	19.5	16
USDA	1.64	28.5	8	1.08	17.5	7	0.87	13.4	5			
Futures[g]	1.36	22.4	25	1.22	19.6	22	1.11	17.9	19	1.00	15.5	9
Soybean meal ($ per ton)												
Chase	18.89	10.6	15	22.40	12.3	12	31.59	17.2	9	44.85	24.1	6
DRI	43.53	25.4	25	45.95	27.4	22	27.27	16.0	19	32.29	18.1	16
Wharton	45.20	28.7	25	48.20	30.2	22	42.15	25.2	19	39.87	22.3	16
USDA	39.46	23.4	7	34.82	20.9	6	25.60	13.8	3			
Futures[h]	40.99	26.6	25	35.10	22.2	22	27.51	17.1	19	23.36	13.7	10
Soybean oil (¢ per lb.)												
Chase	5.10	19.4	15	7.02	26.2	12	7.29	27.9	9	8.19	31.8	6
DRI	5.88	23.3	25	6.32	24.8	22	5.85	22.1	19	6.03	23.6	16
Wharton	5.33	20.7	25	5.19	20.7	22	4.43	17.0	19	4.41	17.2	16
USDA	5.59	20.8	7	5.00	19.4	6	5.65	21.4	3			
Futures[i]	4.49	18.5	25	4.95	19.8	22	5.10	19.6	19	5.04	19.2	10
Cotton (¢ per lb.)												
Chase	7.42	13.0	25	10.54	19.2	22	12.30	21.9	19	11.89	20.0	16
Doanes	6.85	11.9	25	8.80	15.3	22	9.37	15.8	18	8.50	13.3	7
DRI	5.46	9.6	25	8.56	15.6	22	10.98	20.4	19	13.19	24.8	16
Wharton	8.42	15.6	25	9.68	18.[illegible]	22	10.96	20.3	19	9.92	18.4	16
Futures[j]	8.39	15.1	25	11.27	21.6	22	11.65	22.7	19	11.53	21.9	6
Hogs ($ per cwt.)												
Chase	5.39	11.5	25	8.18	17.0	22	10.78	21.9	19	13.01	26.2	16
Doanes	6.09	12.9	25	8.54	18.0	18	11.20	23.1	6			
DRI	5.15	11.0	25	6.90	14.4	22	8.24	16.8	19	8.93	17.9	16
Wharton	6.19	13.2	25	8.24	17.0	22	9.76	19.7	19	10.82	21.4	16
USDA	7.39	15.9	8	10.63	21.8	6	13.88	27.5	3			
Futures[k]	4.80	10.3	25	8.21	17.2	22	10.43	21.7	19	13.20	27.1	9
Live cattle ($ per cwt.)												
Chase	5.19	9.9	25	5.61	12.7	22	8.49	15.6	19	10.45	17.8	16
Doanes	6.12	11.9	25	5.58	12.5	18	6.93	12.8	6			
DRI	5.79	10.3	25	[illegible].89	12.4	22	8.14	14.7	19	10.65	18.1	16
Wharton	6.03	11.0	25	7.23	13.6	22	8.10	14.5	19	10.79	17.6	16
USDA	7.33	12.9	8	10.87	18.9	6	14.91	24.6	3			
Futures[l]	5.25	9.9	25	7.86	14.3	22	10.03	17.8	19	12.75	21.8	9

[a] Root mean squared error.
[b] Root mean squared percentage error.

dors. Chase forecasts are relatively superior for wheat and live cattle and relatively inferior for soybean oil. Doanes performs well for cotton, soybeans, and live cattle; but none of these results are supported by both comparisons. The DRI forecasts are relatively good for hogs and poor for wheat. Wharton performs relatively poorly in forecasting soybeans and possibly soybean meal but relatively well for corn and cotton, depending on comparison. The USDA does well for soybean meal but is relatively a poor forecaster for hogs, live cattle, and possibly wheat.

Comparison of the econometric forecasts with the futures prices, however, reveals some interesting observations. First of all, futures prices tend to dominate the econometric models in forecasting soybean oil, soybean meal, and soybean prices. In fact, soybean meal is the only commodity where any forecast completely dominates all others over all time horizons (in the comparable forecast case). Also, however, futures prices perform quite well as forecasters for wheat and hogs. Over all commodities and horizons, the average rank of the futures forecast is less than 3, which suggests that, at the mode, the econometric models are not able to forecast as well as the futures market. Furthermore, the futures market is the only source of price information other than Doanes which is not significantly inferior for any commodity; and the futures market is significantly superior for as many as four of the eight commodities based on comparable forecasts (table 3, last column), while Doanes is only significantly superior for two commodities at most (and at lower significance levels).

In terms of the earlier discussion, it appears that futures market inefficiencies are not serious and (or) that econometric models do a poorer job of including all relevant exogenous forces, forecasting them, and transforming them into price forecasts than the aggregate intelligence of the futures market. By comparison, average ranks of comparable forecasts over the first three forecast horizons (those horizons where all forecasters produce forecasts) for each respective forecaster are Chase, 3.27; Doanes, 3.17; DRI, 3.5; Wharton, 3.19; USDA, 4.19; and futures, 2.75. Note that these average ranks are slightly biased against Doanes and, to a lesser extent, the USDA since they do not produce forecasts for some of the commodities; thus, average ranks are a bit higher in the commodities which they forecast than in those they do not.

Turning to issues related to time horizon, since traders in the futures market are often closer to cash market phenomena and are often able to make use of new information more quickly than econometric firms, one might expect futures markets to perform better as short-term forecasters. On the other hand, econometric forecasts may be based on better structural information and more careful, longer-run forecasts of the more important exogenous forces. Indeed, examining only the results for comparable forecasts associated with futures market ranks in the lower right-hand side of table 3, the econometric forecasts are generally favored on average for a one-quarter horizon in the case of corn and cotton; corn, cotton, and cattle for a two-quarter horizon; corn and cattle for a three-quarter horizon; and hogs and cattle for a four-quarter horizon. On the other hand, the futures market outranks all commercial econometric forecasts in three of eight cases for a one-quarter horizon, one of eight cases for a two-quarter horizon, four of eight cases for a three-quarter horizon, and, finally, five of eight cases for a four-quarter horizon. Thus, there is no apparent increase in the superiority of the econometric forecasts with a time horizon as one might expect.

Decomposition of Forecast Error

Some additional information regarding the value of various price forecasts for individual decision makers can be gleaned from a de-

[c] Number of observations.
[d] Blanks indicate no forecasts were made.
[e] Futures price as a predictor of No. 1 Hard Red Winter wheat price, Kansas City.
[f] Futures price as a predictor of No. 2 yellow corn price, Chicago.
[g] Futures price as a predictor of No. 1 yellow soybean price, Chicago.
[h] Futures price as a predictor of bulk 44% protein price, Decatur.
[i] Futures price as a predictor of crude tank FOB price, Decatur.
[j] Futures price as a predictor of average price received by farmers, United States.
[k] Futures price as a predictor of seven market average price, barrow and gilts.
[l] Futures price as a predictor of Choice 1,100–1,300 pound slaughter steer price, Omaha.

Table 3. Ranking (and Significance) of Root Mean Squared Errors of Various Commodities by Horizon for Each Source of Forecast, December 1976 through December 1978

Forecast / Component	Best Monthly Forecast Available: Forecast Horizon 1	2	3	4	Sum of Ranks	Forecasts Made in the Same Month: Forecast Horizon 1	2	3	4	Sum of Ranks
Chase										
Wheat	2	1	2	1	6**[b]	2	1	2	2	7**
Corn	4	3	4½	5	16½	3	3	4½	5	15½
Cotton	3	4	5	4	16	4	4	5	4	17†
Soybeans	5	4	4	4	17	6	4	2	4	16
Hogs	3	2	4	3	12	3	3	4	3	16
Live cattle	1	2	4	1	8*	1	1	2	1	5***
Soybean oil	2	5	5	4	16†	5	5	5	4	19†††
Soybean meal	1	1	4	4	10	3	3	3	4	13
Doanes										
Wheat	3	4	3	3	13	4	4	4	4	16
Corn	5	5	4½	3	17½	5	5	3	4	17
Cotton	2	2	1	1	6**	3	2	3	3	11
Soybeans	2	2	5	2	11	1	1	4	2	8*
Hogs	4	4	5	[a]	14	2	5	5		12
Live cattle	5	1	1		7	3	2	1		6*
DRI										
Wheat	6	6	6	5	23†††	6	6	6	5	23†††
Corn	2	2	3	2	9	2	2	2	2	8*
Cotton	1	1	3	5	10	1	3	4	5	13
Soybeans	3	5	3	3	17	2	5	3	3	13
Hogs	2	1	1	1	5***	4	1	1	1	7**
Live cattle	3	3	3	2	11	4	3	4	2	13
Soybean oil	5	4	4	3	16†	3	4	4	3	14
Soybean meal	4	4	2	2	12	5	5	4	3	17††
Wharton										
Wheat	1	3	4	4	12	1	2	3	3	9
Corn	1	1	2	4	8*	1	1	4½	3	9½
Cotton	5	3	2	2	12	2	1	1	1	5***
Soybeans	4	6	6	5	21††	5	6	6	5	22†††
Hogs	5	5	2	2	14	5	4	2	2	13
Live cattle	4	4	2	3	13	5	4	3	3	15
Soybean oil	3	3	1	1	8	2	3	2	2	9
Soybean meal	5	5	5	3	18†††	4	4	5	2	15
USDA										
Wheat	4½	5	5		14½	5	5	5		15†
Corn	6	6	1		13	6	4	1		11
Soybeans	6	1	1		8	4	3	5		12
Hogs	6	6	6		18†††	6	6	6		18†††
Live cattle	6	6	6		18†††	6	6	6		18†††
Soybean oil	4	2	3		9	4	1	3		8
Soybean meal	2	2	1		5**	2	2	2		6*
Futures										
Wheat	4½	2	1	2	9½	3	3	1	1	8*
Corn	3	4	6	1	14	4	6	6	1	17
Cotton	4	5	4	3	16	5	5	2	2	14
Soybeans	1	3	2	1	7**	3	2	1	1	7**
Hogs	1	3	3	4	11	1	2	3	4	10
Live cattle	2	5	5	4	16	2	5	5	4	16
Soybean oil	1	1	2	2	6**	1	2	1	1	5***
Soybean meal	3	3	3	1	10	1	1	1	1	4***

[a] Blanks indicate no forecasts available.

[b] †, ††, and ††† indicate significantly high at a 10%, 5%, and 1% level, respectively; *, **, and *** indicate significantly low at a 10%, 5%, and 1% level, respectively.

composition of forecast errors. For the case where both estimated and actual prices are varying in time, the mean squared error can be decomposed following

$$\frac{1}{n}\sum_{t=1}^{n}(Y_t - X_t)^2 = (\bar{Y} - \bar{X})^2 + \frac{1}{n}\sum_{t=1}^{n}(X_t - \bar{X})^2 + \frac{1}{n}\sum_{t=1}^{n}(Y_t - \bar{Y})^2 - \frac{2}{n}\sum_{t=1}(Y_t - \bar{Y})(X_t - \bar{X}) = (\bar{Y} - \bar{X})^2 + \sigma_X{}^2 + \sigma_Y{}^2 - 2\sigma_{XY},$$

where Y and X are predicted and actual prices, n is the number of observations for a given forecaster and time horizon, $\bar{Y}$ and $\bar{X}$ represent respective sample means, $\sigma_X{}^2$ and $\sigma_Y{}^2$ represent respective sample variances, and σ_{XY} is the sample covariance of X and Y. Thus, the mean squared error decomposes into the bias squared, the variance of the forecast, the variance of the actual price, and minus twice the covariance between the two. This decomposition is reported in table 4. The first term, $(\bar{Y} - \bar{X})^2$, is recorded as the bias squared; the term $\sigma_Y{}^2$ is recorded as the forecast variance; the term $\sigma_X{}^2$ is recorded as the actual variance; and the term $-2\sigma_{XY}$ is recorded as the covariance component. The sum of these four components is the mean squared error, the square root of which is directly comparable to those measures reported in table 2, except that in table 4 only new forecasts are used for the computations. Note that the correlation coefficient is $-\frac{1}{2}$ times the covariance component divided by the square root of the product of forecast variance and actual variance.

One of the interesting implications of table 4 is that not all forecasters seem to be making the same types of errors. For example, in wheat the futures forecast makes most of its errors because of variability in future prices. This implies that some filter might (although not necessarily) average out some of the variability and provide a better forecast. The USDA, on the other hand, makes a large share of its wheat price forecasting errors because of negative covariance between actual and predicted prices, such as might be the case when turning points are missed. The commercial firms such as Chase, DRI, and Wharton make a larger share of their wheat price errors because of bias. Somewhat similar conclusions hold for soybeans.

These same conclusions do not hold for other commodities, however. For example, the econometric firms are remarkably unbiased for cotton, while forecast errors for most econometric models are much more attributable to covariance *vis-à-vis* the futures market. All forecasters commit most of their errors because of bias in hog price forecasting.

It is interesting to consider the extent to which bias can be traded off for lower forecast variance or for lower covariance between forecast and actual prices by choosing one forecast versus another. In point of fact, if a firm's profits are inversely related to forecast error, then a risk-neutral firm may prefer lower bias and be willing to live with higher variance. A risk-averse firm, however, may be willing to use biased forecasts to get greater precision. Also, if costly adjustments are incurred when forecasts are highly variable, then cost-efficiency criteria may also favor lower forecast variance over reduced bias, etc. With this in mind, the wheat price forecasting results, for example, imply that a risk-neutral firm may find futures prices quite adequate forecasters, while a similar risk-averse firm with high cost of adjustment may prefer the lower variability of the Chase, Doanes, or even DRI forecast even though the bias is substantially higher.

These considerations suggest that econometric forecasters with similar overall forecasting ability may be able to differentiate substantially their product to capture specific segments of the market. For example, in soybean price forecasting, the futures prices may appeal to a risk-neutral decision maker, while increasingly risk-averse decision makers or those with higher adjustment costs may turn to Wharton and then to Chase or Doanes as bias is traded for reduced forecast variance (based on one- to three-quarter horizons). Some of these trade-offs are particularly remarkable for soybean oil and meal, where Chase makes most of its errors due to bias, while other forecasters are nearly unbiased.

Finally, comparing the decomposition of errors across commodities, it is interesting to observe the correlation coefficient of forecasts with actual prices after removing bias and variability. For firms interested in turning points and magnitudes of changes, the covariance component may have overriding importance. A positive correlation is reflected by a negative covariance component, i.e., one that

Table 4. Decomposition of Forecast Error for Wheat, Corn, Cotton, Soybeans, Live Cattle, Hogs, Soybean Oil, and Soybean Meal, December 1976, through December 1978

Forecast	Wheat ($/bu.)		Corn ($/bu.)		Cotton (¢/lb.)		Soybeans ($/bu.)		Live cattle ($/cwt.)		Hogs ($/cwt.)		Soybean oil (¢/lb.)		Soybean meal ($/ton)	
	Forecast horizon (quarters)															
Component	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Chase																
Bias squared	0.013	0.038	0.004	0.008	00.51	2.35	0.125	0.278	2.11	5.12	16.85*	54.00*	236.3*	428.0*	18.187*	45.326*
Forecast variance	0.075	0.059	0.061	0.043	68.67	49.16	1.462	0.343	34.47	16.99	30.59	11.77	146.9	30.2	6.720	1.691
Actual variance	0.153	0.141	0.037	0.036	43.28	30.02	1.075	0.641	71.24	66.77	15.82	12.44	100.4	78.4	2.210	0.588
Covariance component	−0.158	−0.114	−0.023	0.035	−57.45	29.61	−0.040	0.218	−80.87	−45.26	−34.20	−11.27	−126.7	−35.0	−1.100	1.620
Correlation coefficient	0.737*[a]	0.623*	0.242	−0.444	0.526*	−0.385	0.015	−0.232	0.815*	0.671*	0.777*	0.465	0.521	0.359	0.142	−0.812*
Doanes																
Bias squared	0.007	0.037	0.012	0.014	5.06	7.06	0.221	0.277	3.03	9.08	25.30*	66.42*				
Forecast variance	0.069	0.053	0.067	0.059	44.85	33.11	1.090	0.487	25.47	17.87	22.03	12.85				
Actual variance	0.106	0.102	0.033	0.030	43.28	30.02	0.917	0.502	71.24	61.81	15.82	13.10				
Covariance component	−0.076	−0.023	0.005	0.056	−46.30	7.17	−0.308	0.030	−62.30	−45.48	−26.01	−19.51				
Correlation coefficient	0.444	0.156	−0.053	−0.665*	0.525	−0.113	0.154	−0.030	0.731*	0.684*	0.696*	0.751*				
DRI																
Bias squared	0.308	0.434	0.003	0.010	6.97	9.57	0.086	0.169	4.06	8.16	7.85	21.79*	21.3	13.6	4.373	4.564
Forecast variance	0.169	0.201	0.032	0.041	49.63	49.50	1.156	0.699	49.26	38.70	38.02	32.44	1,160.7	1,043.0	17.917	17.114
Actual variance	0.149	0.142	0.037	0.036	23.35	15.24	1.075	0.641	71.24	66.77	15.82	12.44	976.6	499.0	8.162	6.959
Covariance component	−0.218	−0.136	−0.012	0.018	−50.10	0.97	−0.270	0.491	−91.06	−66.20	−35.15	−19.00	−263.8	553.6	4.116	<0.001
Correlation coefficient	0.686*	0.402	0.174	−0.234	0.737*	0.0176	0.121	−0.366	0.768*	0.651*	0.716*	0.472*	0.123	−0.383	0.170	−0.000
Wharton																
Bias squared	0.015	0.058	0.007	0.018	0.01	2.49	0.127	0.129	3.16	7.63	22.39*	42.02*	9.9	0.5	3.664	4.886
Forecast variance	0.116	0.075	0.037	0.024	27.53	35.72	1.048	0.938	36.59	25.96	21.22	12.89	1,448.5	1,412.3	9.159	6.936
Actual variance	0.153	0.141	0.037	0.036	43.28	30.02	1.045	0.641	71.24	66.77	15.82	12.44	976.6	499.0	8.162	6.959
Covariance component	−0.209	−0.127	−0.022	0.008	0.05	25.47	0.026	0.536	−74.67	−48.13	−21.15	0.57	−391.9	410.9	7.418	8.135
Correlation coefficient	0.784*	0.617*	0.297	−0.136	−0.001	−0.388	−0.012	−0.345	0.731*	0.578*	0.577*	−0.022	0.164	−0.244	−0.428	−0.585*
USDA																
Bias squared	0.001	0.007	0.030	0.023	[b]		0.006	0.271	11.35	49.78*	25.95*	71.88*	51.7	86.8*	7.417	19.213*
Forecast variance	0.100	0.081	0.065	0.062			1.538	0.520	36.33	8.22	32.25	22.02	820.4	545.5	14.765	5.645
Actual variance	0.109	0.108	0.034	0.033			0.886	0.654	74.47	65.08	17.30	14.35	1,053.0	785.6	6.693	7.278
Covariance component	0.043	0.109	0.024	0.064			0.159	0.799	−79.40	−14.15	−30.29	−7.85	−363.2	874.2	−3.937	9.796
Correlation coefficient	−0.205	−0.583	−0.255	−0.707*			−0.068	−0.685*	0.763*	0.305	0.641*	0.220	0.195	−0.667*	0.198	−0.764*
Futures																
Bias squared	0.001	0.010	0.016	0.041	26.16*	38.37*	0.001	<0.001	7.96	27.41*	9.02	51.13*	35.9	36.5	2.083	4.469
Forecast variance	0.118	0.075	0.034	0.037	75.77	63.66	1.297	0.560	53.03	38.48	33.93	23.33	1,238.5	527.6	11.436	6.601
Actual variance	0.153	0.141	0.037	0.036	43.28	30.02	1.075	0.641	71.24	66.77	15.82	12.44	976.6	499.0	8.162	6.959
Covariance component	−0.197	−0.098	−0.011	0.042	−74.82	−5.10	−0.522	0.275	104.72	70.89	35.73	19.53	−570.5	169.0	−1.488	6.462
Correlation coefficient	0.733	0.476	0.155	−0.575	0.653	0.058	0.221	−0.229	−0.851	−0.699	−0.771	−0.573	0.259	−0.164	0.077	−0.476

[a] An asterisk indicates significant at the 95% confidence level.
[b] Blanks indicate no forecasts were made.

conclusions which may be reached at this point due to small sample sizes.

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observations from two to five months before contract maturity and regression coefficients were less than one for all eight months of lagged observation.

Relative to lagged futures, lagged cash prices yielded mixed results. In general, there is little evidence to support the superiority of either lagged futures or cash prices as forecasts.

Results for live hogs indicate that the statistical hypotheses for all lagged futures observations were accepted. For lagged cash prices, only the hypotheses regarding regression coefficients for observations from three to six months before contract maturity during periods of declining prices were rejected.

The foregoing suggests that live cattle futures have been reliable forecasts during periods of rising prices, but unreliable when prices declined. Second, there was little difference in the forecasting performance of live cattle futures prices relative to lagged cash prices. Third, relative to live cattle futures, live hog futures exhibited superior performance during periods of declining prices. Finally, forecasting performance of live hog futures relative to lagged cash hog prices was marginally superior.

Why the difference in forecasting performance of live hog futures relative to live cattle? The results are consistent with the argument regarding the nature of supply response. Because female slaughter in the beef sector during periods of herd liquidation is a much more significant proportion of total slaughter than for the pork sector, this element of supply response may be more difficult to assess in forecasting total supply and therefore prices of cattle. Hence the poorer forecasting performance of live cattle futures.

Hypothesis (c): Forecasting Performance Differs Seasonally

Differential performance on a seasonal basis may be expected for two reasons. First, seasonal supply and demand factors affect the cash prices of both products. These may be interpreted differently by futures traders. Second, Leuthold (1975) has noted that there is substantial seasonal variation in the volume of futures trading, which could be a factor in forecasting performance.

To determine whether seasonal differences exist, the dummy variable formulation was estimated with the data separated by contract month. Data were grouped by calculating index numbers of monthly cash prices over the entire period for which data were available. If the monthly index values for two months were similar, they were aggregated into a single dummy variable in order to preserve degrees of freedom. The base variable for cattle includes prices for October and December; α_1, β_1 are coefficients for prices in February and April; α_2, β_2 are coefficients for prices in June; and α_3, β_3 are coefficients for prices in August. For hogs, the base variable also includes prices for October and December; and four dummy variables were specified to include February, April, June and July/August, respectively.

The results for cattle show that both cash and futures prices were unbiased forecasts for all months in which futures contracts matured and for observations taken from one to eight months before contract maturity. However, the regression coefficients were different than one for futures prices observed from two to eight months before the October and December contracts matured and from three to eight months before the February and April contracts matured. In contrast, the hypotheses regarding the regression coefficients for lagged cash prices were accepted for six of the eight lagged months for February and April. This suggests that, while cattle futures were generally unbiased and explained movements in cash prices for June and August over the thirteen years of the analysis, they did not generally forecast price movements well for October, December, February, and April. Furthermore, lagged futures prices forecast movements relatively less well than did lagged cash prices for these four months.

The results for hogs indicate that all the futures prices met both the bias and regression coefficient criteria for the seasonal analysis. Lagged cash prices all were unbiased, but the regression coefficient criterion was rejected in four of the lagged months for October/December, two for February, and one for April. According to the criteria established, it is clear that the forecasting performance of live hog futures was acceptable and somewhat better than for lagged cash prices during the fall and winter months. Comparing live hog and live cattle futures, it is also clear that the performance of the live hog market was superior during the fall, winter, and spring months.

Again one questions the reason for the relatively poorer performance of live cattle fu-

tures. We suggest that, because there is a more distinct seasonal pattern in cash hog prices than in cash cattle prices, traders in hog futures are better able to anticipate seasonal price variations. This seasonal pattern appears to be reflected generally in live hog futures prices.

Hypothesis (d): Forecasting Performance Is Different When Economic Conditions Are Unstable Than When They Are Stable

General economic conditions, including prices in the livestock and grain sectors, have been relatively unstable since mid-1973. This period has been characterized by unprecedented inflation, substantial intervention in markets through government policy (e.g., retail price ceilings on meat and an export embargo on soybeans) and unprecedented variations in feed grain prices because of substantial fluctuations in export sales. The effects of inflation and policy intervention on prices are difficult to anticipate. Variations in feed grain prices affect profitability of livestock production and therefore have impacts on supply response. The latter affects livestock prices. Feed grain prices can be a determinant of breeding decisions, female slaughter, the age and weight at which livestock are placed on feed, the length of time they are maintained on feed and, therefore, the weight at which they are slaughtered. The more variable feedgrain prices, the more impact they may have on supply response and the more difficult will be the task of forecasting supply and prices. Thus, our hypothesis is that the forecasting performance of futures prices is better when economic conditions are relatively stable.

To delineate stable and unstable periods, weekly corn prices were plotted over the period from 1965 through 1977. These data showed clearly that both the level and variability of corn prices were substantially higher from May 1973 through the end of 1977 than during the preceding period. Hence the livestock price data were disaggregated to include a relatively stable period before June 1973 (beginning in 1965 for cattle and 1970 for hogs) and an unstable period from June 1973 through the end of 1977. Separate equations were estimated for each period and commodity.

Results for cattle indicate that, before June 1973, both lagged futures and lagged cash prices met the criteria established for prices lagged from one to eight months. However after 1973, while neither lagged futures nor lagged cash prices were biased, the regression coefficients were less than one for all but one month lags. In fact, several regressions resulted in negative coefficients.

For hogs, similar results were obtained, except that both futures and cash prices generally were biased forecasts and the regression coefficients were less than one during the period of variable feed prices. The rather obvious inference to be drawn is that livestock futures performed the forecasting function acceptably when economic conditions were relatively stable, but were unable to forecast well when they were unstable.

Conclusions

Consider the dichotomy about the role of futures for noninventory commodities addressed at the paper's outset. Should livestock futures be regarded as forecasting agencies or as markets for rational price formation? Based on this analysis, the live cattle market clearly has not performed the forecasting function well. Cattle futures appear to add little forecasting information beyond that available in lagged cash prices. Live hog futures appear to perform the forecasting function well relative to both live cattle futures and lagged cash prices, except during periods when economic conditions are unstable. However, the true test of a forecasting mechanism is its performance when forecasting is most difficult. Live hog futures fail the test. Based on these findings, Leuthold and Hartman's suggestion that better informed traders in livestock futures could improve the market's forecasting performance seems fully warranted.

Do livestock futures promote rational price formation? If so, then producers will respond to them and, following Gray's reasoning, the resulting supply response will be incorporated into traders' expectations. Futures prices will then become better forecasts as contract maturity approaches. The lags investigated here are sufficiently long to elicit at least a short-term supply response. Yet, in most cases where forecasting performance was originally poor, it did not improve as contract maturity approached. Hence, the performance of cattle and hog futures as a rational price formation agency is suspect.

Several studies of the hedging potential of livestock futures markets were cited at the

beginning of this paper. They conclude that routine hedging can enhance income stability. This implies that livestock futures markets act as agencies for rational price formation. However, these studies were based on relatively long, aggregated time series. To improve the analysis of livestock futures markets as hedging mechanisms and rational price formation markets, similar analysis should be conducted over disaggregated series as we have done.

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Farmers' Credit Risks and Liquidity Management

Peter J. Barry, C. B. Baker, and Luis R. Sanint

Credit risks are unanticipated variations in costs and availability of credit that arise from forces in financial markets or from lenders' responses to risks in agricultural markets and farmers' creditworthiness. An extension of mean-variance portfolio theory shows how credit risks combine with other financial and business risks to determine total risk. Empirical evidence from lender surveys about risks shows that farmers' credit is positively correlated with changes in farm income, although the correlation is stronger for capital credit than for operating credit, and that variability in fund availability from rural banks has contributed to high credit risks.

Key words: agricultural finance, credit, liquidity portfolio theory, risk management.

Liquidity management is a principal means by which farmers cope with variations in cash flows that arise from uncertain commodity prices, yields, and production costs. The farmer's objective is to assure that cash can be generated quickly and efficiently in order to meet cash demands. Previous studies by Baker (1966, 1968), Baker and Bhargava, Barry and Baker, and Barry and Willmann, have provided much insight on the role of credit in farmers' liquidity management, how credit appraisals differ among lenders, and how farmers' perceptions of these appraisals interact with their managerial decisions. However, these credit concepts and measurement procedures are developed in deterministic terms so that once the composition of credit is known, it is modeled as though it can be relied upon with complete certainty.

Farmers' reliance on credit as a source of liquidity introduces risks in terms of lenders' responses to changing conditions in agriculture and in financial markets that influence their lending decisions and resulting credit availability. These uncertain responses give credit the characteristics of a random variable whose properties can be expressed through the farmers' cost of borrowing. Thus, farmers' credit risk is an added element of their portfolio risk that has not been accounted for in prior analyses. It increases with financial leverage and must be taken into account inasmuch as credit management is a component of overall farm business management.

The purposes of this paper are to further develop concepts underlying farmers' credit risks, to show through an extension of portfolio theory how credit risk may influence farmers' debt use and, thus, firm organization, and to evaluate alternative methods for empirically measuring credit risk. Some empirical evidence is reported on credit risk associated with variations in farmers' incomes and with changes in availability of loan funds at rural banks. Managerial consequences also are developed, using concepts of business and financial risk.

Liquidity Concepts

Liquidity concepts are based on relationships between a firm's composite value of assets and cash proceeds expected from each asset's sale to meet liquidity needs. An asset is considered perfectly liquid if its sale generates cash equal to or greater than the reduction in value of the firm resulting from the sale (Baker 1966). Assets become less liquid as their potential sale reduces the firm's value by more than their expected sales value. Factors generally considered to influence an asset's liquidity include transactions costs, marketability, time allowed for liquidation, liquidity risk, and the asset's impact on a firm's capital integrity.

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Transactions costs include commission charges, installation and assembly costs, transportation and storage costs, opportunity costs, and losses in transit. Marketability refers to characteristics of the market in which the asset is traded. Included are quality of market information, volume of trading, number of participants, development of secondary markets, and other factors that cause differences between an asset's purchase and sale price at a given time (Modigliani). Timing refers to urgency of need for funds with sale proceeds generally increasing as time available for liquidation increases (Pierce). Liquidity risk refers to the relationship between asset values and a firm's stochastic demands for cash (Chen, Jen, Zionts). An asset yielding a high return when cash demand is high is liquidity-preferred. One yielding a low return when cash demand is high is liquidity-averse, and one whose return is independent of cash demand is liquidity-neutral. Among liquidity-neutral assets, those with lower variances are considered to have higher liquidity (Cropper). Capital integrity refers to the importance of an asset's income-generating role in the firm. Liquidations of current assets, like inventories or goods in production, are part of the firm's usual operations. Their effect on firm value largely is reflected directly in its balance sheet. In contrast, liquidations of other assets like machines, breeding livestock, and real estate deplete the firm's income-generating capacity and may reduce the firm's value by more than the asset's sales value. These assets then are illiquid, even though some may have high marketability, low transactions costs, or low liquidity risk.

Holding credit reserves as a source of liquidity provides a means of generating cash that avoids the costs associated with liquidating productive assets to meet cash demands and then reacquiring assets later when adverse conditions have passed. Credit reserves also substitute for cash or cash substitutes as a source of liquidity. Using credit does not greatly disturb a farm's asset structure or production organization, its transactions costs are relatively low, and institutional sources of loan funds generally are available in rural financial markets. However, costs of maintaining and borrowing from credit reserves must be considered. Holding reserves reduces returns from investment opportunities that are foregone from further financial leverage; interest is paid when loans occur; and noninterest charges like deposit balances and loan fees sometimes occur to compensate lenders for establishing lines of credit. Moreover, financial risk must be accounted for in borrowing (Gabriel and Baker), and there is uncertainty about future costs and availability of credit.

Identifying forces affecting the supply of available credit and developing procedures for measuring a farmer's credit risk are complicated by the complexity of credit determinants, Some credit determinants originate in financial markets. Macroconditions attributed to monetary and fiscal policies, structural characteristics of financial markets, and aggregate economic performance may influence costs and availability of loan funds; so may microconditions that characterize financial intermediaries. These financial market conditions are far removed from farmers' operating environments and may have little or no influence on farmers' cash demands. They influence, but are not influenced by, farmers' credit management. Hence, farmers can only monitor them as part of their financial environment.

Other determinants of credit supply originate in agriculture through macroeffects of supply-demand conditions for commodities and resources, and through microeffects of farmer-lender relationships that reflect the lenders' concept of farmers' creditworthiness. Creditworthiness is evaluated on the basis of evidence farmers supply to assure lenders that lending risks will be minimal and that debt servicing will meet the terms of the loan contract.

In gaining these assurances, lenders consider a farmer's personal characteristics and credit history, managerial qualities, wealth position including collateral offered as loan security, and income and repayment expectations. These financial factors often are translated into credit limits through commonly used rules-of-thumb.[1] The limits may be modified further to reflect managerial characteristics, security position, and financing practices of individual operators, as in the cases of younger, low equity borrowers, unsecured notes, risk-reducing practices, installment contracts, trade credit, and so on.

[1] Examples are lenders' willingness to loan up to 75% of farmland's current market value, to require a 40% margin of equity in cattle placed on feed, to loan up to 75% of a crop's expected sale value, and to aim for an overall debt-equity ratio not to exceed 1.0.

The lending rules reflect risk premiums that lenders associate with the contingency of having to liquidate the various assets being financed, while still providing sufficient funds to cover the indebtedness. The lending rules produce a credit limit. The difference between the credit limit and the actual loan disbursement is the credit reserve. Moreover, as borrowing occurs, the farmer's remaining credit reserve becomes more volatile in response to changes in asset values and income expectations. Hence, credit reserves are expected to decline (increase) with lower (higher) market values of crops, livestock, machines, and land at rates that increase as leverage increases.[2]

These features of creditworthiness mean that the effects of asset characteristics on liquidity are similar, whether evaluated by a farmer or by a lender. That is, the effects of transactions costs, marketability, time, liquidity risk, and capital integrity are about the same, whether asset liquidation occurs by a farmer or by a lender, in the event that a loan reaches forceable liquidation. In general, then, the liquidity risk characteristics of assets extend to holdings of credit reserves. Credit is positively correlated with net values of assets, given the firm's liability structure, and is positively correlated with net income expectations, given the repayment commitments.

Credit Risk and Portfolio Analysis

Risks associated with costs and availability of credit are an added element of farmers' portfolio risk that influence debt use and resulting capital structure for risk-averse farmers. Hence, it is appropriate to include the effects of credit risk in farm firm analysis in order to evaluate its effects on farmers' portfolios and to serve as a guide for further empirical analysis. These effects are shown here by extending the mean-variance portfolio model explicitly to include risk properties for costs of borrowing, and by deriving an expected utility-maximizing farm portfolio that accounts for these measures of credit risk.

The mean-variance approach is well known and much debated, especially about the limited generality of its assumptions. However, its widespread use (Robison and Brake), its explicit measures of risk, and rigorous demonstration (Tsiang; Levy and Markowitz) of its usefulness as an approximate method for portfolio selection help make it an acceptable model for showing the portfolio effects of credit risk.

Consider a risk-averse farmer who must choose a level of debt (D) with which to leverage equity (E) in financing risky production with total assets (A). Expected returns before interest and taxes and variance from investment in risky assets are designated $\bar{r}$ and σ_r^2, respectively. When credit is specified only in deterministic terms, the cost of using credit in borrowing is expressed as rate $i = i_b + i_r$, with both components having zero variance. Component i_b is the interest rate paid the lender, and liquidity premium i_r is the farmer's value of the credit reserve. When credit is treated as a random variable, the cost of using credit in borrowing is expressed as expected rate $\bar{i}$, with variance σ_i^2, and covariance σ_{ri} with returns from risky assets. Hence, risk is treated in probabilistic terms with variance used to measure likelihoods of events occurring that produce results less than expected.

To show a closed-form solution, let the farmer's utility function be approximated by the negative exponential,

$$U(\pi) = 1 - e^{-2\lambda\pi}, \tag{1}$$

where λ is the degree of risk aversion ($\lambda > 0$), and π is the level of income. Freund has shown that maximizing the expected value of a negative exponential integrated over a normal density function, as is assumed for r and i, is equivalent to maximizing

$$E[U(\pi)] = E(\pi) - \lambda\sigma_\pi^2. \tag{2}$$

Notation $E(\pi)$ and σ_π^2 now represent the expected profits and variance, respectively, of the farmer's portfolio. Expected profits are defined as the returns to assets less the cost of borrowing

$$\pi = \bar{r}A - iD. \tag{3}$$

Portfolio variance is

$$\sigma_\pi^2 = \sigma_r^2A^2, \tag{4a}$$

where cost of borrowing is deterministic, and

$$\sigma_\pi^2 = \sigma_r^2A^2 + \sigma_i^2D^2 - 2AD\sigma_{ri}, \tag{4b}$$

where the cost of borrowing is a random variable. Expression (4b) is the variance of the

[2] Credit relationships discussed here are not specific to any one lender. The concepts can be extended to include risks of credit availability from primary lenders and from secondary lenders like merchants and dealers, finance companies, and government agencies.

difference between two random variables. Hence, the covariance term has a negative sign preceding it, indicating that the lower (higher) is the correlation between r and i, the greater is the increase (reduction) in total portfolio variance (Fama, pp. 226–9).

For the deterministic credit case, substituting the expressions in equations (3) and (4a) into equation (2) yields

$$(5) \quad E[U(\pi)] = E[\bar{r}A - iD] - \lambda[\sigma_r^2 A^2].$$

Substituting $D + E = A$ and considering the level of debt (D) as the decision variable, the first-order condition for an expected utility-maximizing level D^* is

$$(6) \quad dU(\pi)/dD = \bar{r} - i - 2\lambda\sigma_r^2 D - 2\lambda\sigma_r^2 E = 0,$$

which gives optimal debt of

$$(7) \quad D^* = \frac{\bar{r} - i - 2\lambda\sigma_r^2 E}{2\lambda\sigma_r^2}.$$

Differentiating (7) with respect to $\bar{r}$, i, λ, σ_r^2, and E shows the following comparative static properties:

$$(8a) \quad dD^*/d\bar{r} = \frac{1}{2\lambda\sigma_r^2} > 0,$$

$$(8b) \quad dD^*/di = \frac{-1}{2\lambda\sigma_r^2} < 0,$$

$$(8c) \quad dD^*/dE = -1 < 0,$$

$$(8d) \quad dD^*/d\lambda = \frac{-\bar{r} + i}{2\lambda^2\sigma_r^2} < 0,$$

$$(8e) \quad dD^*/d\sigma_r^2 = \frac{-\bar{r} + i}{2\lambda\sigma_r^4} < 0.$$

Optimum debt is positively related to changes in expected returns on assets and inversely related to changes in costs of borrowing, equity, variance of returns, and risk aversion.[3] In the latter two cases, the inverse relationships hold as long as expected return on assets is greater than the cost of borrowing.

When credit risks are introduced, the expression for expected utility maximization becomes

$$(9) \quad E[U(\pi)] = E[\bar{r}A - \bar{i}D] - \lambda[\sigma_r^2 A^2 + \sigma_i^2 D^2 - 2AD\sigma_{ri}].$$

Again, substituting $D + E = A$ and considering the level of debt as the decision variable, the first-order condition for an expected utility-maximizing level D^* is

$$(10) \quad dU(\pi) = \bar{r} - \bar{i} - 2\lambda\sigma_r^2 D - 2\lambda\sigma_r^2 E - 2\lambda\sigma_i^2 D + 4\lambda D\sigma s_{ri} + 2\lambda E\sigma_{ri} = 0,$$

which gives optimal debt of

$$(11) \quad D^* = \frac{\bar{r} - \bar{i} - 2\lambda E(\sigma_r^2 - \sigma_{ri})}{2\lambda(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})}.$$

Comparison of expressions for optimal debt in equations (7) and (11) indicates that the addition of risk measures for credit will mostly warrant lower use of debt, although the result depends strongly on the level of covariance σ_{ri}. If, for example, covariance is zero, then debt use clearly is less in expression (11). However, if covariance is strongly positive, then optimal debt could be higher in expression (11). This is shown by setting equations (7) and (11) equal to each other and solving for σ_{ri}. The result is

$$(12) \quad \hat{\sigma}_{ri} = \frac{\sigma_i^2(2\lambda\sigma_r^2 E - \bar{r} + \bar{i})}{2(\lambda\sigma_r^2 E - \bar{r} + \bar{i})}.$$

As long as the actual σ_{ri} is less than $\hat{\sigma}_{ri}$, optimal debt in equation (11) will be less than optimal debt in equation (7). Suppose, for example, that the variables have the following values: $\bar{r} = .12$, $\bar{i} = .08$, $\sigma_r^2 = .0016$, $\sigma_i^2 = .0004$, $\lambda = .0000624$, and $E = \$100{,}000$. The values: $\bar{r} = .12$, $\bar{i} = .08$, $\sigma_r^2 = .0016$, $\sigma_i^2 = .0004$, $\lambda = .0000624$, and $E = \$100{,}000$. The pression (11) to exceed its value in (7).

Comparative static properties for equation (11) are

$$(13a) \quad dD^*/d\bar{r} = \frac{1}{2\lambda(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})} > 0,$$

$$(13b) \quad dD^*/d\bar{i} = \frac{-1}{2\lambda[\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})} < 0,$$

$$(13c) \quad dD^*/d\lambda = \frac{-\bar{r} + \bar{i}}{2\lambda^2(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})} < 0,$$

$$(13d) \quad dD^*/d\sigma_r^2 = \frac{-\bar{r} + \bar{i} - 2\lambda E(\sigma_i^2 - \sigma_{ri})}{2\lambda(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})^2},$$

$$(13e) \quad dD^*/dE = \frac{-(\sigma_r^2 - \sigma_{ri})}{\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri}},$$

[3] The trade-off between equity and debt in expression (8c) appears unusual. However, it is consistent with the constant absolute risk-aversion assumption for a negative exponential utility function. Hence, for this utility specification, increasing wealth (E) does not cause a change in holdings of risky assets (A); rather, it allows a reduction in risk-free debt while holding constant the level of risky assets. Holdings of risky assets, and thus debt, would only increase with increases in equity if risk aversion (λ) decreases or if some other parameter value changes accordingly.

$$(13f)\quad dD^*/d\sigma_i^2 = \frac{-\bar{r} + \bar{i} + 2\lambda E(\sigma_r^2 - \sigma_{ri})}{2\lambda(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})^2}$$

$$(13g)\quad dD^*/d\sigma_{ri} = \frac{\bar{r} - \bar{i} + \lambda E(\sigma_i^2 - \sigma_r^2)}{\lambda(\sigma_r^2 + \sigma_i^2 - 2\sigma_{ri})^2}.$$

These results are more ambiguous than in expressions (8a) through (8e). In all cases, the denominator values are nonnegative. However, only (13a) and (13b) have definitive numerator values: debt use is positively related to changes in asset returns and inversely related to borrowing costs. The relationship between debt and risk aversion also is inverse if expected asset returns exceed expected borrowing costs. Debt responses to changes in other parameters cannot be fully evaluated without knowing their values.

Measuring Credit Risks

Measuring farmers' credit risks would be simplified if lenders' risk responses were expressed solely as adjustments in risk premiums on interest rates for loans, rather than through nonprice responses. Then, the response of interest rates on individual loans to changes in farm risk would show the part of farmers' credit risk that is attributed to their creditworthiness. Similarly, the relationship between interest rate changes induced by conditions in financial markets and changes in farm loan demand would show the part of credit risk attributed to market forces. However, measurement of credit risk is hampered by lack of explicit risk pricing on loans by lenders to reflect their judgment about farmers' creditworthiness and availability of loan funds.

Nonprice Credit Responses

Interest rates on loans from major nonreal estate farm lenders like rural banks and production credit associations seldom vary much among individual borrowers. Even when rates do vary, the response may be more to differences in loan sizes and costs of lending than to differences in risk. Instead, lenders' risk responses to differences in farmers' creditworthiness primarily occur in nonprice ways that include differing loan limits among borrowers, and differences in security requirements, loan maturities, loan supervision and documentation, and other means of credit administration (Baker1968; Barry and Willmann; Robison and Barry).

Changes in availability and cost of loan funds that arise from forces in financial markets are more likely to be expressed in interest rates, although differences in sources and uses of funds among major types of farm lenders cause other differences in their loan policies. Farm Credit System (FCS) lenders, for example, acquire most of their loan funds from national financial markets through sales of consolidated bonds or discount notes that occur under highly competitive conditions. Hence, their access to loan funds is constrained only by their capacity to pay market interest rates. In turn, loan funds are priced to farm borrowers with variable interest rates that are adjusted periodically for changes in average cost of funds, reserve or capital requirements, or other intermediation costs. These loans also are considered exempt from state usury laws. So, observations on changes in interest rates on FCS loans should closely indicate the part of farmers' credit risk that is attributed to changes in financial market conditions.

In contrast, factors affecting fund availability for rural banks have been much more insulated from national financial markets than for FCS and for larger urban banks. Rural banks rely heavily on local markets for attracting deposits as their major source of funds. Demand deposits have had no interest cost, and historically rates on all time deposits but large, negotiable certificates of deposits have had legal limits. In periods of rising interest rates, these banks often experience disintermediation as deposit funds are attracted to other investments (Benjamin).[4] These banks also are subject to considerable fluctuation in farm and farm-related loan demands in their local market. Combined effects of these conditions have generated periodic stresses in rural banks' liquidity and relatively high fluctuation in availability of loan funds for farmers. Moreover, relatively few farm loans from rural banks are priced with variable interest rates.

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[4] Availability in late 1978 of money market certificates with 6-month maturities and with minimum denominations of $10,000, and availability of 30-month time deposits both of whose rates are indexed to U.S. government securities appear to have greatly freed up banks' capacity to bid for deposit funds. These developments together with anticipated phase-out of regulation Q and liberalization of usury limits on loan rates may bring a substantial shift during the 1980s to reliance on price rather than nonprice credit responses by rural banks. However, the relative uses of price and nonprice responses to individual loan customers may still continue to depend heavily on levels of loan competition in rural financial markets.

Data from the Federal Reserve System indicate that in early 1980 only about 11½% of the amount of farm loans by U.S. banks with less than $400 million in total assets occurred with a floating (variable) rate. Use of floating rates increased slightly with size of farm loans and increased greatly for the largest banks.

Lenders' nonprice responses to changes in farm risks and to changes in financial market conditions, especially in rural banks, mean that attempting to measure linkages between historic changes in interest rates, farm risks, and farm loan demands is not a fully effective way to reflect farm credit risks. Instead, estimates are needed on how lenders' nonprice responses are related to farm risks and farm loan demands. Moreover, the lenders' nonprice responses also make it difficult to express credit risk in terms of a farmer's costs of borrowing, as occurs in the preceding portfolio analysis.

Costs of Borrowing and Nonprice Responses

The relationship between farmers' costs of borrowing and lenders' nonprice credit responses to risk is shown by using earlier approaches to optimal credit use that account for farmers' liquidity premiums (i_r) on credit reserves (Barry and Baker; Baker and Bhargava). This approach specifies optimal credit use as an equilibrium reflecting equality at the margin between a payoff schedule from using borrowed funds in the farm business and a cost-of-borrowing schedule that includes both the interest obligation to the lender and a credit reservation price reflecting the farmer's liquidity premium on the maintained credit reserve. The liquidity premium signifies the liquidity risk component of the farmer's total portfolio risk and is determined by the level of risk aversion.

Panel A of figure 1 shows, for example, that a farmer who exhibits increasing cost of using credit in borrowing V_i and decreasing payoff from borrowing V_L will allocate total credit OC to borrowing in amount OA (70%) and to reserve in amount AC (30%). However, total credit OC now is considered a random variable that is characterized by a probability distribution (P) with mean $\bar{c}$ and standard deviation, σ_c. Once borrowing occurs in amount OA, events that reduce (increase) total credit will be absorbed entirely by reduction (increase) in the credit reserve. A loss (gain) in credit reserve will raise (lower) the farmer's

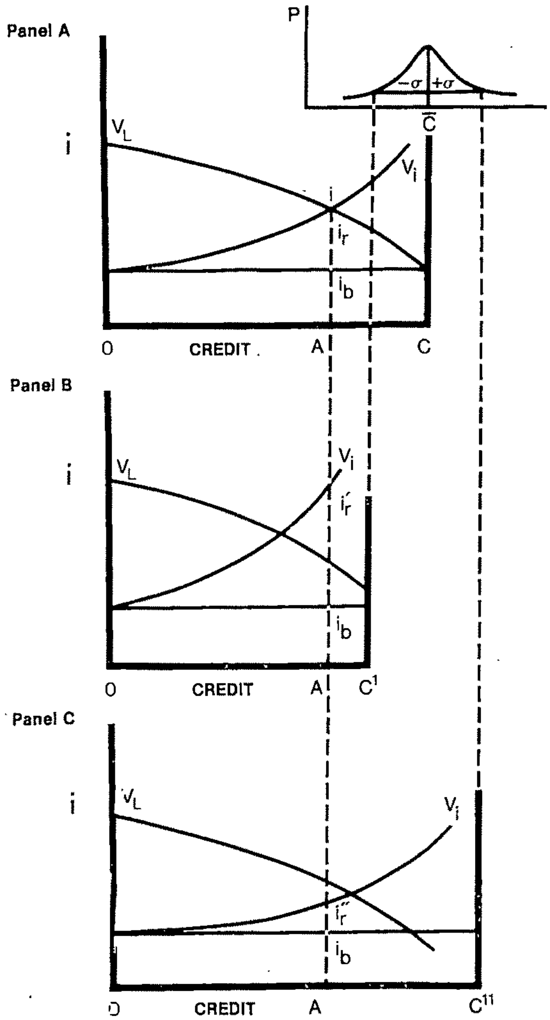

Figure 1. Credit variations and costs

liquidity premium on the remaining reserve, and thereby increase (lower) his total cost of borrowing. This approach assumes that any reduction in credit reserve does not exceed the previously maintained credit reserves, thus forcing asset liquidation or other responses.

Suppose, as indicated in panel B, that total credit is reduced by 20% to OC^1. Original borrowing in amount OA means that 87.5% = (70%/80%) of credit OC^1 now is committed to borrowing, with only 12.5% in reserve. Cost of borrowing increases to $i' = i_b + i_r'$ because of the increased liquidity premium; hence, credit allocation now is nonoptimal. Alternatively, if total credit increases by 20% to OC'' (panel C), borrowing of OA means that 58% = (70%/120%) of credit OC'' now is committed to borrowing, with 42% in reserve. Cost of borrow-

ing then declines to $i'' = i_b + i_r''$ because of the lower liquidity premium.

Hence, variations in the lenders' nonprice responses, shown here by variations in credit limits, are directly related to changes in a farmer's costs of borrowing. Similarly, measures of credit risk shown earlier as variance in borrowing cost and covariance with asset returns can be expressed by the variance of credit and its correlation with factors affecting farmers' financial performance and their demand for loans.

The following analysis focuses on procedures for measuring two components of farmers' credit risk: variation of credit limits in response to risks in farm operations and variation of rural banks' availability of loan funds relative to farmers' loan demands.

Credit Supply and Farm Risks

The procedure for testing the hypothesis that farmers' supply of credit is positively correlated with changes in level of farm income is to simulate a case farm whose level and standard deviation of expected income are estimated from a historic time series of prices, yields, and costs (Sanint). Credit evaluations for the case farm then are elicited from a sample of lenders based on selected gain and loss conditions for farm income. In turn, the likelihoods associated with the gain and loss conditions are derived with risk parameters estimated from the historic series. Thus, a "moderate gain" might be the occurrence of actual income that is 1.0 standard deviation above the expected value; a "favorable gain" might be actual income that is 1.5 standard deviations above the expected value. Similarly, "moderate loss" and "severe loss" might be occurrences of actual incomes that are 1.0 and 1.5 standard deviations, respectively, below the expected value. In this way, the resulting variations in lenders' credit responses can be correlated with variations in farmers' income on the basis of the latter's known statistical properties.

This approach was implemented by following credit elicitation procedures of earlier studies (Baker 1968; Barry and Willmann) where lenders responded through a survey to a case loan request for a representative farming situation. Here, the loan request contains the case farmer's needs for operating expenses, capital expenditures, and other cash obligations for the coming year. The total loan request was set high enough to anticipate the lenders' rejection and designed for deletion of individual items until loan approval was obtained.[5] The approved loan request then signifies total borrowing capacity for each risk condition.

Loan documentation was provided by statements showing financial performance for three risk conditions experienced by the farmer in the preceding year. Two replications of this procedure accounted for the moderate and severe cases. In the first replication lenders were asked to indicate the total loan granted for average and moderate gain-loss conditions experienced by the farmer in the preceding year. The average case assumed that the farmer experienced an average or expected level of performance in the preceding year. The moderate-loss case assumed that the farmer experienced a below-average level of performance in the preceding year with a combination of prices and yields resulting in farm receipt levels that might occur in one out of six years. The moderate-gain case assumed that the farmer experienced above-average performance in the preceding year with prices and yields resulting in gains that might occur in one out of six years. These levels of variation fall roughly within one standard deviation of the expected value.

The second replication differed from the first only in the magnitude of gain and loss experienced by the farmer. Results for the loss and gain cases reflected income conditions that might occur in one out of fifteen years—occurring about 1.5 standard deviations from the expected value. In all cases, the representative farm was characterized as a young, established farmer whose management ability and prior credit record were known. Hence, variations in income were due to random factors and the single year of financial data was set against a longer, successful credit history. Moreover, the sequence of borrowing needs and type of lender were fixed so that these factors did not influence the lenders' credit responses.

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[5] The operating loan request was designed to cover expenses for crop production and postharvest storage, term-loan payments, and family needs. Most of these outlays reflect fixed obligations that a farmer must meet to continue his operation, although financing needed for crop storage is more flexible because sales from inventory will generate cash for other uses. In contrast, capital purchases for growth, modernization, or replacement offer greater flexibility because they generally can be postponed or cancelled without jeopardizing the firm's immediate operations.

Besides the designation of loan limits for these risk conditions, lenders also were asked about other loan terms that might reflect their response to the case farmer's risk position. Included were interest rates charged on the loan under the stipulated farm income conditions, security or collateral requirements, and any other loan requirements. Thus, while the survey focused on total borrowing capacity for the various farm risk conditions, it also showed other potential risk responses by lenders.

A mail survey was sent in fall 1979 to 101 unit banks and production credit associations (PCAs) in south central and eastern Texas. Banks in the sample were required to have more than $1.2 million in farm loans to assure familiarity with farm financing. Half of the institutions received replication one and the other half received replication two, so that the complexity of risk cases and credit responses was kept to a minimum for the respondents. Fifty lending institutions responded to the survey; however, sixteen responses were voided for several reasons: failure to make this type of loan, large loan size, lack of time to complete the survey. Thirty-four useful responses occurred from twenty-five banks and nine PCAs, with nineteen responses from replication one and fifteen responses from replication two.

Table 1 reports farm financial characteristics and sizes of loan request for the five income cases and averages of the lenders' loan limits for each risk case. Averages of loan granted are indicated in dollar values and as percentages of original loan request. Using percentages accounts for differences in size of the operating loan requests for the loss situations that result from the need for additional, carryover financing.

Survey results indicate a positive relationship between the farm's credit and the level of farm income in the preceding year. The average loan granted and percentages of loans granted are small for the loss situations, and increase as the case farm's income conditions become more favorable. As an example, the percentage of total loan granted increases from 57% for the severe loss to 82% for the favorable gain.

However, the results also indicate that lenders differentiate their credit response between operating and capital loans. Most of the credit adjustment occurs for capital purchases, where the percentage of loan granted ranges from 16% for the severe loss to 69% for the favorable gain. In contrast, credit for operating needs, including carryover loans, is more stable, with percentages of loan granted ranging from 78% for the severe loss to 90% for the favorable gain.

Table 1. Results of Lender Survey for Farmers Income Variation

	Farm Income Conditions					
	Case 1:	Case 2:	Case 3:		Case 4:	Case 5:
	Severe Loss	Moderate Loss	Average Conditions Rep. 1	Average Conditions Rep. 2	Moderate Gain	Favorable Gain
Farm characteristics						
Farm receipts ($)	63,893	84,498	125,707	125,707	166,917	187,520
Additions to retained earnings ($)	(45,690)	(25,085)	11,036	11,036	28,154	35,198
Net worth ($)	239,619	260,224	296,345	296,345	313,463	320,507
Debt-to-equity ratio	.79	.65	.50	.50	.46	.44
Loan request ($)						
Operating loan expenses	127,549	127,549	127,549	127,549	127,549	127,549
Carryover	34,482	17,877	0	0	0	0
Capital purchase loan	76,550	76,550	76,550	76,550	76,550	76,550
Total loan request	242,581	221,976	204,099	204,099	204,099	204,099
Average loan granted ($)						
Operating	125,676	120,493	111,309	112,428	116,482	114,524
Capital	11,967	15,592	37,078	36,368	50,349	52,705
Total	137,643	136,085	148,387	148,795	166,831	167,229
Percentage loan granted						
Operating	78	83	87	88	91	90
Capital	16	20	48	48	66	69
Total	57	61	73	73	82	82

Analysis of variance (ANOV) of lenders' credit responses used a two-way, incomplete, random block design to test for significant differences among levels of farm income and among individual lenders. Preliminary results using one-way ANOV had shown that, while lenders exhibited similar patterns of credit response to changes in farm income, much variation occurred among lenders in the levels of their credit responses across all farm income levels. That is, some lenders exhibited much more liberal credit responses than others. Hence, the two-way approach accounts for both income and individual lender effects in the credit response.

ANOV results show that differences in percentages of total loans granted (total credit) among income levels and among lenders were statistically significant at the 5% level. Furthermore, Duncan's test grouped the loss, average, and gain cases, respectively, but showed no significant differences between the two loss cases or between the two gain cases. ANOV results for capital credit were essentially the same as those for total credit. ANOV for operating credit also showed significant credit responses to changes in income, although the Duncan test identified the severe loss case as the most prominent source of variation. After variation in credit responses attributed to the individual lender effects is removed, resulting partial correlation coefficients between credit and farm income were estimated at .66 for total credit, .82 for capital credit, and .37 for operating credit.

Hence, these results are consistent with the hypothesis that farmers' credit is positively correlated with changes in level of farm income, although the correlation appears stronger for capital credit than for operating credit. In turn, positive correlation between credit and income implies negative correlation between farmers' costs of borrowing and farm income. These numerical results also are consistent with many lenders' written comments on the survey indicating that, when occasional farm losses are anticipated, both farmer and lender must exert careful financial control to see the operation through the adverse period. Restricting capital transactions is a favored control mechanism. Lenders also appear more responsive to the occurrences of loss or gain, than to their actual magnitudes. The credit response for a moderate loss or gain, relative to the average case, appears much more significant than does the credit response between a moderate and severe loss, or between a moderate and favorable gain. This lack of strong response to the extreme conditions may reflect the lender's lack of sharing in the farmer's short-run profits or losses. The credit responses might differ for two or more consecutive years of loss or gain.

Survey responses about other methods of risk response by lenders indicated small differences in security requirements, although security interests in crops, machinery, and equipment were unanimous. In some cases, liens on real estate and credit life insurance were required. No differences in interest rates occurred among lenders or among the risk cases. Banks' market interest rates were high enough to be limited by state usury laws, although PCA rates were not restricted by usury. Hence, nonprice loan methods were the lenders' sole response to the simulated farm risks.

Credit Supply and Loan Fund Availability

To evaluate farmers' credit risks associated with loan fund availability at rural banks, statistical measures are derived for bankers' observations about changes in farm loan demands and changes in fund availability. Bankers' observations are taken from responses of several hundred agricultural member banks in the Seventh Federal Reserve District to quarterly surveys about farm lending conditions conducted by the Federal Reserve Bank of Chicago. Included in these surveys are questions about loan demand, fund availability, loan repayment rates, loan-deposit ratios, and other credit-related information. Bank responses are aggregated and reported as relative frequencies or averages (Federal Reserve Bank of Chicago; Board of Governors of the Federal Reserve System).

On several items, banks are asked whether conditions during the current quarter of the year are higher, lower, or the same as in the year-earlier period. Index numbers then are computed by subtracting the percentage of bankers that respond "lower" from the percentage that respond "higher" and adding 100. Hence, index values above 100 indicate higher average values than a year earlier; index values below 100 indicate the opposite condition.

Figure 2 charts the pattern of changes in the indexes for farm loan demand and fund avail-

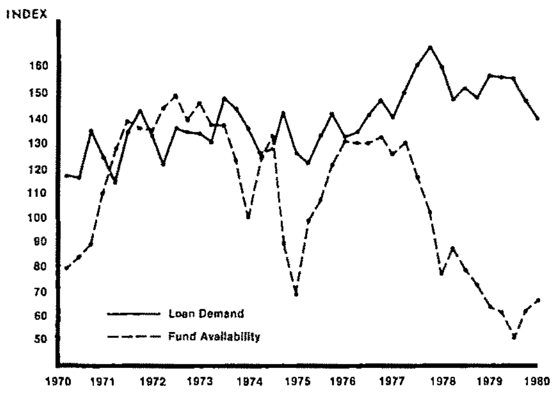

Figure 2. Loan demand and fund availability

ability for the 1970–1980 period. Since 1970, the index for farm loan demand ranged from a low of 114 in the first quarter of 1971 to a high of 169 in the third quarter of 1977. Hence, banks' observations of continued growth in farm loan demand are indicated by the index always remaining above 100. In contrast, the index of fund availability shows much variation with several movements around 100. Indeed, the later portion of the time period shows much disparity in the two indexes with fund availability reaching a decade low of 51 in the second quarter of 1979.

Table 2 shows several statistical measures for the quarterly series of index values for the period beginning in 1970 and extending through the first quarter of 1980. The coefficient of variation for the fund availability index is relatively high, especially in comparison with the coefficient for the loan demand index. This high variability in fund availability implies high variability of farmers' credit reserves. It thus adds to variance of farmers' borrowing costs through the liquidity premium portion of the cost of borrowing. In turn, higher variance of borrowing costs adds to farmers' portfolio risk.

Farmers' credit risks are further influenced by the correlation between changes in loan demand and fund availability, although the relationship depends upon the cause of change in farm loan demand. Suppose that strong loan demand primarily is attributed to favorable farm income expectations. Then, using the covariance relationship in equation (4b) and recalling that the cost of borrowing and changes in credit reserves are inversely related, the lower the correlation between fund availability and loan demand, the smaller is the resulting portfolio risk. The condition implies that farmers' costs of borrowing are high when loan demands resulting from favorable income are high. In contrast, if strong loan demand results from farmers' needs for loan extensions, loan carryovers, or other liquidity purposes, then lower correlations between fund availability and loan demand will add to portfolio risk. Credit reserves would be smaller when liquidity needs are greater.

Results in table 2 show that indexes for farmers' loan demand and banks' fund availability have a covariance of −63.29 and a correlation coefficient of −.16. This low correlation could imply a stabilizing effect on farmers' portfolio risk, which offsets in part the risk added by variance of fund availability. However, the combined effects of several factors, including both business growth and liquidity needs, likely influenced farmers' loan demands over this time period (Federal Reserve Bank of Chicago). Hence, further study is needed of how factors influencing loan de-

Table 2. Measures of Credit Conditions at Seventh Federal Reserve District, Agricultural Banks, 1970–80

Index	Mean	Standard Deviation	Coefficient of Variation	Fund Availability Covariance	Fund Availability Correlation
Loan demand	137.73	13.48	.098	−62.39	−.16
Fund availability	107.24	29.41	.274		
Banks with loan-to-deposit ratio above desired level	105.59	24.80	.235	690.52	.95
Average loan-to-deposit ratio	58.24	4.43	.076	−104.84	−.80

mand are related to fund availability and farmers' risks.

Other evidence about fund availability is shown by relationships between the index for fund availability, the index of bank preferences for loan-deposit ratios, and actual loan-deposit ratios. Loan-deposit ratios are considered a general indicator of bank liquidity. While not shown in figure 2, the index of banks' preferences for lower loan-deposit ratios closely follows the pattern of the fund availability index; moreover, the correlation coefficient between these two indexes for the 1970–1980 period is .95. Hence, the loan-deposit preference index may serve as an alternative indicator of fund availability; fund availability is low when banks prefer lower loan-deposit ratios. Moreover, banks' actual loan-deposit ratios also show a close relationship with fund availability, although the relationship is inverse, as reflected in a correlation coefficient of −.80. Thus, the index for fund availability is low (high) when the actual loan-deposit ratio is high (low).

An important feature of these survey responses is that the bankers' observations likely are closely related to their expectations about future credit conditions. These expectations presumably are used in managing bank portfolios and making credit decisions. However, it is not clear whether the observations on loan demand might reflect transfers of farm customers to other lenders, or whether observations on fund availability indeed are independent of changes in loan demands. Hence, several sources of bias may influence the banks' survey responses.

Concluding Comments

Concepts and empirical results reported here have shown that credit reserves, valued in part for their role in risk aspects of financial management, are themselves subject to risk. Therefore credit risk also must be accounted for in farmers' total portfolio risk, and in analysis of risk and liquidity management. Indeed, if credit becomes too volatile, it loses value as a source of liquidity, thereby forcing farmers to seek other more costly sources.

The practical implications for risk management largely are empirical ones that depend on characteristics of specific farm situations. However, some general guidelines arise from this analysis. As an example, portfolio analyses earlier in the paper showed that the addition of risk measures for credit generally will lead to lower use of debt by farmers, although in selected circumstances relatively high covariances between borrowing costs and asset returns could warrant higher use of debt. Similarly, very high covariance could warrant increased debt in response to increase in business risk. In practice, these responses are unlikely since responses of surveyed lenders indicated a strongly positive relationship between credit and level of farm income, implying a negative relationship between borrowing costs and levels of income. Hence, greater business risk is associated with higher borrowing cost, thus favoring lower leverage. Moreover, relatively high variability of fund availability from rural banks adds to farmers' credit risk, thus favoring lower leverage.

The differences in lenders' responses between operating and capital credit are important too. While operating credit appears more stable than capital credit, reduction in availability of operating credit may trigger other adjustments to sustain the farm's operations. Examples might include reductions in operating inputs, changes in enterprises, sales of capital assets, or changes in marketing plans (storage, hedging) that reduce needs for inventory financing. Alternatively, farmers might seek other sources of financing, refinancing into longer-term loans, or access to government loan programs. Similar responses might occur for fund availability problems at rural banks.

Higher variation in availability of capital credit shows that financing capacity for firm growth is strongly linked to business performance, at least in the preceding year. Moreover, restricting capital credit is a favored means of financial control for lenders. Implications for macroinvestment analysis also are evident in the tendency for changes in credit availability rather than changes in interest rates, especially for rural banks, to serve as key methods of financially constraining farm investment and growth.

Clearly there is need for further empirical and conceptual research on measuring credit risks and on evaluating appropriate responses by farmers, by lenders, and by public policy. The results obtained here are based on credit measures with rather limited geographic scope and small sample size; however, it would be surprising to find that results differ much for other locations, other farm types, other lend-

ers, or larger samples. These measures also focused on lenders' nonprice responses to farm risks and to financial market forces. More study is needed of interest rate responses, especially to financial market forces. Rural banks, for example, are expected to become more price responsive in the future, although time and experience are needed to verify these expectations.

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Determinants of Public Services Provision in Rural Communities: Evidence from Voting on Hospital Referenda

Rodney D. Fort and Jon B. Christianson

There has been considerable recent research regarding the determinants of consumer demand for collectively provided goods, but relatively little of this research has focused on rural areas or issues that are particularly important to rural residents. In this paper, a public choice analytical framework is adopted to analyze voting behavior on rural hospital referenda. The results of the analysis aid in understanding support given by rural residents to low occupancy, rural hospitals and in predicting opposition to public sector efforts to close such facilities.

Key words: public services, referenda, rural hospitals, voting.

The purpose of this paper is to identify factors influencing support for rural hospitals as revealed through voting outcomes on hospital referenda. In the past, several researchers have noted the relative lack of empirical research based on well-developed theoretical models of community service provision in rural areas (Day, Jones and Gessaman, Eddleman, Brunn and Jones, Jones and Murdock, Dunn and Doeksen). In particular it has been observed that little is known regarding rural consumer preferences for collectively provided goods and services (Jones and Gessaman, p. 942; Eddleman, p. 959; Brunn and Jones, p. 46; Vlasin, Libby, Shelton, p. 900; Jones and Murdock, p. 955; Freeman, p. 917) and the roles which institutional factors and special interest groups play in explaining observed levels of service provision (Jones and Gessaman, p. 937; Eddleman, pp. 959–60; Brunn and Jones, pp. 379; Vlasin, Libby, Shelton, p. 908; Dunn and Doeksen, p. 53). The analysis of voting patterns on referenda pertaining to rural public services has been identified as one potentially productive method for addressing these issues (Jones and Gessaman, p. 942; Vlasin, Libby, Shelton, p. 907; Freeman, p. 917).

In analyzing voting behavior on rural hospital referenda, the paper adopts the public choice analytical framework suggested in this journal by Ostrom and by Arnold. Central to the public choice approach is the incorporation of the individual consumer as an integral component in a theory of collectively provided services (Arnold, p. 860), as well as the explicit consideration of the impact of institutional design on collectively provided service levels (Ostrom, p. 849). Hence, the analysis addresses some of the shortcomings in the existing literature as cited above.

The paper is organized in four parts. First, a description is provided of hospital referenda and their policy importance. Then a theory of individual utility maximization in the presence of both private goods and collectively provided hospital capital is developed. This theory is placed within a specific institutional context that emphasizes the potential for special interest groups to influence the level of rural hospital referenda expenditures. Third, the modifications of the theory required for empirical application are described. In particular, the example of other authors is followed in adopting a "representative voter" approach to accommodate the aggregated nature of available socioeconomic data and secret ballot vot-

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ing results. Hence, although grounded in a theory of individual behavior, the empirical interpretations pertain more generally to "community" support for rural hospitals (Deacon and Shapiro). Finally, an empirical analysis is conducted of voting behavior in rural hospital referenda as a function of the explanatory variables suggested by the theory, and the results of this analysis are interpreted.

Background

In accordance with the National Health Planning and Resource Development Act (1974), guidelines for health planning were issued by the Department of Health, Education, and Welfare in 1978. Among other recommendations, the guidelines suggest that a maximum of four hospital beds per thousand people and a minimum of an 80% occupancy rate for these beds are desirable for an efficient hospital system (Zwick). Rural hospitals typically exhibit occupancy rates considerably lower than the recommended 80% and therefore are regarded as inefficient because these low occupancy rates are believed to result in higher than necessary hospital costs. These costs presumably are reflected in charges, area insurance premiums, and state and federal Medicaid and Medicare reimbursements for rural hospital services, thereby shifting some of the burden imposed by the excess capacity to taxpayers and insurance purchasers outside of rural areas. One implication of the guidelines is that these collective costs could be reduced through reductions in rural hospital capacity so long as the reductions did not significantly impair access to acute care for rural residents.

In the policy debate surrounding the guidelines, rural residents have strongly supported low occupancy rural hospitals, citing the importance of the facilities to local economies and their usefulness in attracting physicians and providing emergency medical services (Zwick). Furthermore, rural residents point out that they often subsidize hospital operating losses with local tax revenues, thereby accepting a portion of the social costs which might result from the inefficient use of resources implied by low occupancy rates. The analysis below attempts to illuminate this policy debate by identifying the important determinants of support for rural hospitals using a well-defined economic framework. Voting outcomes on hospital referenda in rural areas are particularly well suited as empirical indicators of support within such a framework. Pommerehne and Schneider argue that the incentive for voters to make informed decisions is greatest in referenda elections because these elections address one well-defined issue. Typically, the debates prior to the vote on a hospital referenda are vigorous, and the ballot choices are clearly stated. Hence there is relatively little voter uncertainty about tax effects and total expenditures. This makes the personal benefit-cost calculus of voters less complicated than for other types of elections and reduces the incentives for voters to be "rationally ignorant." Therefore, by relating referenda voting outcomes to characteristics of voting populations and of the referenda themselves, it is possible to identify important determinants of support for hospitals in rural areas.

The typical rural hospital referendum process is initiated when the desire for a facility is made known to elected officials by a local "health contingency" composed of physicians, health care administrators, and concerned elements of the general population. In the abstract, Romer and Rosenthal (1978, 1979a, b) refer to this group of influential citizens as the "setter." The hypothesized goal of the setter is public expenditure maximization. Based primarily on the setter's advice, the policy maker then proposes the level of the referendum. The referendum usually takes one of three forms: funds for building a new hospital where none existed previously, funds for building a hospital to replace an existing facility, or funds for remodeling or expanding an existing hospital. Typically, the referendum is characterized by the health contingency as an "all-or-nothing" proposition. For the first category, a new hospital, the threat is that physicians will leave the rural community (or will not be attracted to the area) unless the facility is built. In the remaining cases, the threat is that physicians will leave and/or that Medicare/Medicaid accreditation will be lost, forcing the facility to close, unless the referendum is passed. Thus, voters are faced with an apparent choice between the tax expenditure associated with referendum passage or alteration of the current level of hospital services should the referendum fail to pass.

Model

Assume that an individual *i*, confronted with a hospital referendum voting decision, pos-

sesses a well-behaved utility function incorporating (for simplicity of exposition) only collectively provided hospital services g, and a privately provided good x:

$$(1) \qquad u^i = u(g,x).$$

Adopting the approach of Mikesell and Blair in their analysis of voting on school referenda, hospital services are assumed to require capital (w) and labor (l) inputs,

$$(2) \qquad g = g(w,l).$$

It is assumed that a unique level of labor is associated with each level of collectively provided hospital capital. This assumption is reasonable in light of Medicare/Medicaid regulations requiring specific numbers and types of personnel per hospital bed. Hospital services then can be treated as a variable affected only by adjustments in the level of hospital capital:

$$(1') \qquad u^i = u(g(w),x).$$

In this simple, two-good world, the individual budget constraint is

$$(3) \qquad I^i = px^i + rv^i$$

where I^i is income of the ith individual, p is price of one unit of the privately provided good, x^i is units of the privately provided good consumed by the ith individual, r is mill rate levied to cover the cost of collectively provided hospital capital, and v^i is assessed value of taxable property possessed by the ith individual.

The mill rate is assumed to be determined by the collective taxing authority from the balanced budget constraint

$$(4) \qquad h[g(w)] = G[g(w), I^c] + rV,$$

where $h[g(w)]$ is the cost of a given level of collectively provided hospital capital, V represents the total assessed value of all community taxable property, and I^c is the community income level. The specification of G in equation (4) allows for intergovernmental grants. Historically, the level of rural hospital capital stock has been influenced by federal grants under the Hill-Burton Program. Hill-Burton grants were related positively to the amount of proposed spending for hospital construction and negatively to the community income level (Lave and Lave). Solving (4) for the mill rate, r, substituting into (3), and rearranging terms yields the consumer's reduced private-social budget constraint,

$$(5) \qquad I^i = px^i + \frac{v^i}{V}\{h[g(w)] - G[g(w), I^c]\}.$$

The highest attainable level of individual utility occurs where (1′) is maximized subject to constraint (5). It can be demonstrated that optimal consumer behavior results in the allocation of expenditure so that the marginal utility per dollar spent on x and $g(w)$ is equal. (The mathematical development is available in mimeographed form from the authors.) Furthermore, in equilibrium the consumer's valuation of the additional utility from a change in hospital capital stock just equals the consumer's additional cost resulting from that change. However, the individual is not free to attain a personal optimum level of $g(w)$ because the level of hospital capital is the result of a nonincremental, collective decision. Hence, a theory that unifies the individual optimization strategy and the institution of voting is required.

Assuming that the constraint in equation (5) is satisfied, the optimal level of private consumption can be expressed in terms of price, disposable income, and a predetermined level of collectively provided hospital capital. The highest attainable level of utility for individual i can be written as

$$(6) \qquad \max u^i = U_k{}^i(p_k, g(w_k), I_k{}^i - \frac{v^i}{V}\{h[g(w)] - G[g(w), I^c]_k\}).$$

A change in public policy toward provision of hospital capital would affect those variables with the k subscript. (Since v^i/V is in part choice-determined, its inclusion as a parametric variable on the right-hand side of (6) is not strictly valid. However, this does not alter the essential model results.) A referendum confronts the voter with a choice between two alternative outcomes. Let $k = 0$ denote the outcome if the referendum fails to pass, and let $k = 1$ denote the outcome if the referendum does pass. The highest attainable utility levels associated with each outcome are $U_0{}^i$ and $U_1{}^i$, respectively:

$$(7) \qquad U_0{}^i = U^i[p_0, g(w_0), I_0{}^i - \frac{v^i}{V}(h - G)_0],$$

$$(8) \qquad U_1{}^i = U^i[p_1, g(w_1), I_1{}^i - \frac{v^i}{V}(h - G)_1].$$

The voting rule consistent with utility maximization is vote YES if $U_1{}^i > U_0{}^i$, otherwise

vote NO. This voting rule abstracts from the case where $U_1^i = U_0^i$. With equal alternative utility levels, it is possible that the voter may abstain; however, the voter's presence in the booth is taken as evidence that this condition is not in force.

Data and Empirical Modifications

Explanatory variables expected to influence the individual's voting decision can be identified conveniently in terms of the difference in potential utilities under referendum passage and referendum failure (Deacon and Shapiro). This difference in potential can be written in "change notation" as

$$(9)\quad U_1^i - U_0^i = \Delta U^i\Big(\Delta p, g(\Delta w),\ \Delta I^i - \frac{v^i}{V}\,\Delta\{h[g(w)] - G[g(w), I^c]\}\Big),$$

where Δp, Δw, ΔI^i, and $\frac{v^i}{V}\ \Delta\ (h - G)$ represent differences in private goods prices, hospital capital, income, and tax bill.

An empirical test of the model was developed based on voting results in rural hospital referenda in ten states (Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, North Dakota, South Dakota, Utah, Wyoming) during the years 1946–1978. Through an initial survey of 542 county clerks in August 1979, 152 health care referenda were discovered. Of these referenda, sixty-nine elections relating only to hospitals were chosen for analysis. A subsequent, more detailed, survey produced complete data on voting outcomes and referenda characteristics in fifty-five cases, including seven elections involving new hospitals where none existed previously, eighteen elections involving additions to existing hospitals, and thirty elections involving replacement hospitals.

The categories of explanatory variables selected for empirical analysis included (*a*) the level of hospital capital that would prevail under passage of the referendum, w_1; (*b*) the level of capital associated with referendum failure, w_0; (*c*) income, I^i; (*d*) expected income changes due to passage or failure of the referendum, ΔI^c; (*e*) the prices of collectively provided hospital capital to the representative resident, v^i/V; and (*f*) intergovernmental grants. Unfortunately, data limitations required the use of proxy measures in the empirical estimation of the model. For instance, the exact nature of the capital stock which would result from a referendum passage, w_1, would be uncertain from the voter's perspective. Therefore a proxy variable was defined for w_1 that was simply the referendum dollars which would be spent per county resident. This approach also was adopted by Mikesell and Blair (p. 405) and Borcherding and Deacon (p. 893). In explaining use of this proxy in analysis of school referenda, Mikesell and Blair argued that "school district community service expenditure per pupil . . . introduces visibility of both latent and manifest functions provided by the school plant and facilities. Higher levels of these expenditures will increase individual perception of the public output from school buildings and, hence, the percentage of voters favoring a bond issue" (p. 405). Similar expectations were held with respect to the influence of expenditure per capita in voting on rural hospital referenda.

Proxy measures also were required for the level of hospital services the voter expected to prevail if the referendum failed (w_0). Two alternative descriptions of hospital capital stock levels under referendum failure (or "reversion" levels of capital stock) were compared for analysis of cases where there were existing facilities. If the voter expected to lose the existing facility in the event of referendum failure, then the voter-anticipated available hospital capital was assumed equal to that level associated with the next best alternative, defined as the facility nearest the one threatened with closure. (This also was adopted as the reversion level in referenda for new facilities, with the alternative defined as the nearest facility to the county seat.) On the other hand, if the voter did not believe the threat of facility closure, then the set of characteristics describing the present facility (the "status quo") was assumed to describe the relevant reversion level expected by the voter.

The variables chosen to reflect capital stock levels under each assumption were (*a*) the size of the hospital, *S*, measured by the number of beds; (*b*) the percentage of occupancy rate during the year of the election, 0, indicating the average availability of hospital capital; (*c*) the age of the building, *a*, a proxy for the condition of the structure itself; and (*d*) the road distance from the existing facility or the county seat to the nearest alternative, *D*, indicating response time and travel costs associated with utilization of the capital stock.

Because the referenda analyzed in this study involved changes in the property tax rate, the perceived cost of added services depended on the assessed value of an individual's taxable property. When

$$(\frac{v^i}{V})_A > (\frac{v^i}{V})_B,$$

and the A and B subscripts indicate different counties, the implication is that desired levels of collective hospital capital would be greater in county B than in county A. The proportional tax cost for the representative individual in each county was approximated by dividing the median county housing value by the total county taxable property value. (The conditions under which this empirical measure of tax impact can be interpreted as reflecting different desired levels of spending are described in detail by Barr and Davis [p. 152] and appear valid for the theoretical model developed in this paper).

The model also suggests that intergovernmental grants through the Hill-Burton Program would affect the voter's decision. Data were available on (*a*) the expenditures specified in the sample referenda and (*b*) the hospitals in the sample receiving Hill-Burton funds. Unfortunately, it was not possible to ascertain whether expenditures specified in the referenda covered the difference between total project cost and Hill-Burton monies. Hence, a precise estimate of the effect of Hill-Burton money on net county cost $\{h[g(w)] - G[g(w), I^c]\}$ in equation (9) was unobtainable. However, data were available to construct binary variables defined as (*a*) Hill-Burton funding within eight years prior to the election and (*b*) within eight years after the election. It was hypothesized that the presence of Hill-Burton funds would have a positive effect on the probability of a yes vote, *ceteris paribus,* because the county would not actually receive the approved funds unless the balance of the total cost were covered. The omitted category was "no Hill-Burton funding" within eight years of the election.

Income variables suggested by the model include the income of the representative voter at the time of the referendum, I^i, and expected changes in income under passage and failure of the referendum ΔI^i. While I^i can be measured by median household income, perceived changes in income are unobservable. Past studies have addressed this problem by identifying groups within the population that could be expected a priori to experience changes in income due to changes in hospital output. The proxies used for empirical analysis were (*a*) the percentage of the county population which was employed full time in the existing facility at the time of the referendum and (*b*) the percentage of the county population which was employed in retail and wholesale establishments. The latter was adopted as a proxy for a group in the community which would be affected by changes in hospital expenditures and the expenditures of hospital visitors.

It also was expected that aggregate voting results would be related to the relative size of groups of potentially high demanders in the referenda counties (Deacon and Shapiro). Consequently, the following variables were introduced: the percentage of the county population over sixty-five years of age and the birth rate per thousand population in the county.

In addition to the explanatory variables described above, two sets of variables were included in the empirical analysis as controls. First, the year of the referendum was used to control for institutional changes over time, such as the introduction of Medicare and Medicaid reimbursements. Second, two binary variables were utilized to differentiate among the types of issues covered by the referenda: new hospitals where none previously existed, replacement of existing hospitals, and additions to existing hospitals.

In summary, a framework for estimating aggregate community responses to proposed changes in hospital capital levels was developed in a previous section of the paper. While secret ballot voting procedures preclude estimation of any particular individual's demand, the existence of known voting outcomes for small geographic areas does allow inferences to be made about community preferences from aggregate behavior, subject to the following types of assumptions. First, because voting outcome data are available only in an aggregate form, it must be assumed that summary, and some cases proxy, values for explanatory variables can be used in place of individual values. (All monetary variables were expressed in real terms using 1967 dollars. A complete description of data and sources is available from the authors upon request.) Second, since actual voting outcomes are to be explained and values used for some of the explanatory variables pertained to the general population (not just voters), it must be assumed that the characteristics of voters coin-

cide with the characteristics of the general population. Finally, it was assumed that no changes in the prices of private goods were anticipated by voters because of changes in hospital capital stock.

Results

Three basic linear models were estimated:

(10) $Y = \alpha + \beta x + \epsilon$,
(11) $Y = \alpha' + \beta' x + \theta s + \epsilon$, and
(12) $Y = \alpha' + \beta' x + \gamma t + \epsilon'$,

where s is a set of characteristics describing the alternative reversion level of capital stock, t is a set of characteristics describing the status quo reversion, $\mathbf{x}$ is a vector containing all other explanatory variables, Y is a variable representing voting behavior, ϵ is a normally behaved error term, and the α's, β's, θ's, and γ's are model parameters.

The logit model specification was adopted for estimation of equations (10–12). This specification assumes that the probability of voting yes for any individual is logistically distributed. (Pindyck and Rubinfeld, p. 247). In logarithmic form it reduces to

$$\log \frac{Pr(Y)}{[1 - Pr(Y)]} = \alpha + \beta \mathbf{X}, \tag{13}$$

where $Pr(Y)$ is the probability of a yes vote given the vector of explanatory variables, $\mathbf{X}$. With repeated sample observations for given values of the explanatory variables, $Pr(Y)$ can be approximated using the ratio of yes votes to total votes in a given election. Therefore, equation (13) becomes

$$\log \left(\frac{Y}{N}\right) = \alpha + \beta \mathbf{X}. \tag{14}$$

Cox (pp. 33–34) has demonstrated that an amended version of the model performs better for small sample data:

$$\log \left(\frac{Y + 1/2}{N + 1/2}\right) = \alpha + \beta \mathbf{X}. \tag{15}$$

Further, since the specification in equation (15) is characteristically heteroskedastic (Kmenta, p. 426) weighted least squares is appropriate. The weights applied to both sides of (15) in estimation were the inverses of the square roots of the variances of the dependent variable (Intriligator, pp. 165–173). These weights attach greater importance to referenda with a large number of voters as well as to referenda where the voting outcome is close.

Table 1 presents the results of estimating equations (10)–(12) using the weighted logit technique. Evidence concerning the explanatory power of the reversion capital stock levels is revealed in four ways. First, none of the characteristics chosen to represent either reversion level are significant individually at the 80% confidence level. In addition, an F-test reveals that these characteristics, taken together, do not contribute significantly to the explanation of the probability of a yes vote for either specification. Third, all capital stock characteristics taken together (i.e., all characteristics pertaining to both the alternative reversion and the status quo reversion combined) do not contribute significantly to the explanation of the probability of a yes vote. Finally, the F-value for the alternative reversion set of characteristics is significant at the 77.7% confidence level while the F-value for the status quo reversion set of characteristics is significant at the 76.8% confidence level. This small difference suggests that neither reversion specification is preferable on statistical grounds. (Given the small difference between these significance levels, the test statistic suggested by Pesaran [1974] was not computed.)

For equation (10), the basic model in table 1, the following results are consistent with a priori expectations (significance levels are in parentheses): (*a*) the probability of a yes vote decreases as the cost $\frac{v^i}{V}$ of collectively provided hospital capital to the representative voter increases (99%); (*b*) the greater the proportion of residents who stand to gain in terms of increased business interplay with the hospital and its visitors, the more probable is a yes vote (99%); (*c*) the probability of a yes vote increases if Hill-Burton funds were approved within eight years prior to the election relative to the omitted category, "no Hill-Burton funds" (80%); and (*d*) changing preferences and institutional arrangements over time have increased the probability of a yes vote (80%).

Two highly significant empirical results deserve special attention. First, referenda for replacement hospitals increase the probability of a yes vote relative to referenda for new hospitals where none existed previously (99%). Apparently, rural communities which have

Table 1. Empirical Results

Variables	Basic Model	Alternative Reversion	Status Quo Reversion
a. Price	−1.512	−1.338	−1.348
	(5.947)	(4.303)	(5.134)
b. Income	.00001	−.00012	−.00001
	(.106)	(.805)	(.081)
c. Expenditure per capita	−7.220	−6.977	−7.307
	(5.172)	(3.446)	(4.857)
d. Retail-wholesale employment	13.004	17.883	12.017
	(2.848)	(3.353)	(2.547)
e. Hospital employment	−1.036	61.133	38.948
	(.017)	(.352)	(.562)
f. Over 65	−7.821	−7.387	−9.133
	(1.220)	(1.[illegible]10)	(1.338)
g. Birthrate	.0094	.0008	.0074
	(.338)	(.025)	(.232)
h. Hill-Burton, before	.763	.991	.643
	(1.926)	(2.091)	(1.605)
i. Hill-Burton, after	−.040	−.109	−.295
	(.112)	(.286)	(.788)
j. Additions	.286	−.239	−.013
	(.537)	(.357)	(.022)
k. Replacements	1.302	.760	1.060
	(2.954)	(1.568)	(1.949)
l. Referenda year	.048	.045	.045
	(1.509)	(1.212)	(1.341)
Reversion variables			
a. Number of beds		.002	.002
		(1.144)	(.512)
b. Occupancy rate		−.004	.[illegible]08
		(.520)	(.878)
c. Age of building		.010	.014
		(.934)	(1.141)
d. Distance		.016	
		(1.080)	
Statistics			
R^2	.977	.979	.980
Adjusted R^2	.970	.971	.972
Degrees of freedom	42	38	39
Sample size	55	55	55
Overall F-Value	147.968	117.467	123.199

Note: t-values are given in parentheses.

experienced a local hospital are stronger supporters of hospital referenda than communities where no hospitals exist. Second, the probability of a yes vote is inversely related to levels of expenditure per capita (99%). This result is counter to expectations. The theoretical model hypothesized that voters made their decisions by comparing the utility levels associated with passage or failure of the referendum. Therefore any element of the referendum proposal that decreased utility was expected to have an adverse effect on the probability of a yes vote. The empirical result that higher relative expenditure per capita levels decreased the probability of a yes vote implies that if rural residents could have more expenditure per capita at the same price, they would not desire it. Possible explanation of this finding is that residents of rural counties are debt-averse.

At first glance, the significant negative coefficient on the expenditures per capita variable does not seem to conform with the fact that rural hospital elections pass with few exceptions. One explanation for this apparent inconsistency is based on the distribution of benefits and costs from the provision of rural hospital capital through debt financing. The empirical results suggest that voters involved in retail and wholesale trade are likely to be supporters of rural hospital referenda. This outcome is consistent with the hypothesis that this group of voters, and other groups like them, receive concentrated benefits from an increase in hospital capital. Conversely, the costs associated with an aversion to collective debt are likely to be diffused across all voters. It is expected that those voters who stand to gain substantially are more likely to vote than are other rural residents. Further, the goals of these potential gainers are in accordance with the hypothesized public expenditure maximization goal of the setter. Hence, to the extent that the untility positions of potentially decisive voting groups are enhanced, the setter can act to increase expenditure-per-capita levels and still be confident of referendum passage. The utility gains from concentrated benefits outweigh the utility losses generated by aversion to debt. It is important to note that while this explanation may be intuitively appealing, the aggregative nature of the voting data does not permit careful examination of whether such groups are actually decisive. It would be necessary to employ individual voting data to explore in detail the validity of explanations such as this.

The empirical results which are not significant also deserve brief discussion. The variable for median family income of the rep-

resentative voter is insignificant and its sign changes under the two reversion capital stock specifications. One explanation for this outcome is the existence of multicollinearity among the independent variables. Regression results indicate that 99.7% of the variation in income can be explained by variation in the other independent variables. This problem also plagues the variables for hospital employment (R^2 = .958), percentage of the population over sixty-five (R^2 = .990), and birthrate (R^2 = .982). It is interesting to note that the coefficient for percentage of the population over sixty-five, which is nearly significant at the 80% level, has a negative sign. It was hypothesized that the elderly would be characteristically high demanders of hospital capital because of their greater than average demands for hospital services. An explanation for the opposite result may be that the elderly are averse to paying in the present for capital investments yielding long-run benefits which they may never capture. Alternatively, one could speculate that this group holds a relatively high proportion of the value of county taxable property and thus bears concentrated present costs if the referendum passes.

Conclusions

A theoretical model of voting on rural hospital referenda was developed and tested in this paper. The results have at least two interesting policy implications. First, it appears that increases in hospital capital expenditures per capita will not enhance the probability of referenda passage, all else remaining equal. This tends to indicate general dissatisfaction with the levels of public expenditures specified in the elections studied. However, the elections typically pass despite this dissatisfaction. One explanation of this outcome focuses on the distribution of benefits and costs from rural hospital provision, an explanation which cannot be explored empirically using the "representative voter" methodology employed in this paper.

A second conclusion of interest is that the characteristics of the hospital capital stock which would prevail if the referenda failed are not significant explanatory variables in the analysis. Yet, these variables commonly are offered in heuristic explanations of support for hospitals in rural areas. Instead, variables such as price and the relative importance of benefiting groups are statistically significant and consistent with a priori hypotheses. This suggests that support for rural hospitals and opposition to rural hospital closures will be strong in counties with relatively low personal property taxes and high concentrations of benefiting groups.

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Estimating Farm-Level Input Demand and Wheat Supply in the Indian Punjab Using a Translog Profit Function

Surjit S. Sidhu and Carlos A. Baanante

Application of the translog profit function to farm-level data from Punjab, India, allowed a more disaggregated analysis of the farm production structure compared to the case of Cobb-Douglas formulation. The flexibility afforded by translog formulation permitted measurement of the different impacts that exogenous variables have within and across input demand and output supply functions. Policy-relevant elasticity estimates with respect to variable inputs and output prices, fixed inputs, a few soil-related "state-of-nature" variables measured by soil analysis, and education, which are usually considered constraints to farm production, were obtained, and two examples of policy applications were developed.

Key words: constraints, disaggregated analysis, farm production structure, flexibility, soil analysis, state of nature, translog profit function.

The econometric applications of the new production theory based on the duality relationship between production functions and variable profit functions represent a major step forward toward generating appropriate empirical estimates of agricultural supply and input demand functions which are crucial for applications of economic theory for agricultural development policy (Lau and Yotopoulos 1971, 1972; Yotopoulos and Lau; Yotopoulos, Lau, Lin; Sidhu; and Sidhu and Baanante). Furthermore, the development of flexible functional forms by Diewert (1971, 1973, 1974); Christensen, Jorgensen, and Lau; and Lau (1974, 1976) permits applications of the duality theory for a more disaggregated analysis of the production structure than has been possible by traditional approaches.[1] Thus, the need to aggregate heterogenous exogenous factors that are expected to differ in their impact within and across input demand and output supply functions is considerably reduced, and the use of an array of environmental factors is possible.

The purpose of this paper is to apply the normalized, restricted, translog profit function and the corresponding system of derived demand to the farm-level data for Mexican wheat varieties (MWV) from the Indian Punjab in order to generate policy-relevant empirical estimates for wheat supply and input demand functions. In addition to the usual types of variable and fixed inputs, a few soil-related, "state-of-nature" variables measured by actual soil analysis and education are included in this analysis.

The Translog Profit Function Model

In this section we first present a brief exposition of the concept of translog profit function and then develop some basic derivations to compute various input demand and output supply elasticities. The formulations constitute the basis for empirical implementation of the model in the next section.

A generalization of the normalized restricted translog profit function for a single output is given by Diewert (1974); Christensen, Jorgensen, and Lau:

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[1] This is not to suggest that the traditional functional forms, for example, the Cobb-Douglas, are not appropriate for several other types of analyses, only that their use to study the details of structure of production is restrictive.

$$(1)\quad \ln \pi^* = \alpha_o + \sum_{i=1}^{n} \alpha_i \ln P^*_i + \tfrac{1}{2}\sum_{i=1}^{n}\sum_{h=1}^{n} \gamma_{ih}\ln P^*_i \ln P^*_h + \sum_{i=1}^{r}\sum_{k=1}^{m} \delta_{ik}\ln P^*_i \ln Z_k + \sum_{k=1}^{m} \beta_k \ln Z_k + \tfrac{1}{2}\sum_{k=1}^{m}\sum_{j=1}^{m} \phi_{kj}\ln Z_k \ln Z_j,$$

where $\gamma_{ih} = \gamma_{hi}$ for all h, i, and the function is homogenous of degree one in prices of all variable inputs and output. The definition of the variables and the notation used are as follows: π^* is the restricted profit—total revenue less total costs of variable inputs—normalized by P_y, the price of output; P^*_i is the price of variable input X_i, normalized by P_y, the price of output; Z_k is the kth fixed inputs; $i = h = 1, 2, 3, \ldots, n + k = j = 1, 2, 3, \ldots, m$; ln is the natural logarithm; and α_o, α_i, γ_{ih}, δ_{ik}, β_k, and ϕ_{kj} are the parameters.

Define $S_i \equiv P^*_i X_i/\pi^*$ as the ratio of variable expenditures for the ith input relative to restricted profit. Let $S_v \equiv V/\pi^*$ be the ratio of output supply (V) to normalized, restricted profit. Note that S_v is also equivalent to the ratio of the total value of output to restricted profit. Differentiating the translog profit function (1) with respect to $\ln P^*_i$ and $\ln P_y$ gives a system of variable input/profit ratio functions and an output supply/profit function (Diewert 1974; Christensen, Jorgensen, Lau). Because, however, the S_i and S_v sum to unity, the output supply equation can be ignored, and only the variable input equations and the translog profit equation (1) need be used for econometric estimation:

$$(2)\quad S_i = -\frac{P^*_i X_i}{\pi^*} = \frac{\partial \ln \pi^*}{\partial \ln P^*_i} = \alpha_i + \sum_{h=1}^{n} \gamma_{ih}\ln P^*_h + \sum_{k=1}^{m} \delta_{ik}\ln Z_k.$$

Profits and variable inputs are determined simultaneously. Under price-taking behavior of the farms, the normalized input prices and quantities (levels) of fixed factors are considered to be the exogenous variables.

Now, suppose that parameter estimates of equations (1) and (2) have been obtained. Then, the elasticities of variable input demands and output supply with respect to all exogenous variables evaluated at averages of the S_i and at given levels of variable input prices (for the case of fixed factors) are linear transformations of the parameter estimates of the profit function.[2]

Variable Input Demand Elasticities

From (2) the demand equation for the ith variable input can be written as

$$(3)\quad X_i = \frac{\pi}{P_i}\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(4)\quad \ln X_i = \ln \pi - \ln P_i + \ln\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right).$$

The own-price elasticity of demand (η_{ii}) for X_i then becomes

$$(5)\quad \eta_{ii} = \frac{\partial \ln X_i}{\partial \ln P_i} = \frac{\partial \ln \pi}{\partial \ln P_i} - 1 + \frac{\partial \ln}{\partial \ln P_i}\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(6)\quad \eta_{ii} = -S^*_i - 1 - \frac{\gamma_{ii}}{S^*_i},$$

where S^*_i is the simple average of S_i.

Similarly, from (4) the cross-price elasticity of demand (η_{ih}) for input i with respect to the price of the hth input can be obtained:

$$(7)\quad \eta_{ih} = \frac{\partial \ln X_i}{\partial \ln P_h} = \frac{\partial \ln \pi}{\partial \ln P_h} + \frac{\partial \ln}{\partial \ln P_h}\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(8)\quad \eta_{ih} = -S^*_h - \frac{\gamma_{ih}}{S^*_i},$$

where $i \neq h$.

The elasticity of demand for input i (η_{iy}) with respect to output price, P_y, can also be obtained from (4):

$$(9)\quad \eta_{iy} = \frac{\partial \ln X_i}{\partial \ln P_y} = \frac{\partial \ln \pi}{\partial \ln P_y} - \frac{\partial \ln P_i}{\partial \ln P_y} + \frac{\partial \ln}{\partial \ln P_y}\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(10)\quad \eta_{iy} = \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i}\cdot\frac{\partial \ln P_i}{\partial \ln P_y} - (-1) - \sum_{h=1}^{n} \frac{\gamma_{ih}}{S^*_i}(-1),$$

where $i = 1, \ldots, n$, $h = 1, \ldots, n$,

$$(11)\quad \eta_{iy} = \sum_{i=1}^{n} S^*_i + 1 + \sum_{h=1}^{n} \frac{\gamma_{ih}}{S^*_i}.$$

---

[2] In the case of the translog cost function, the input demand elasticities, evaluated at average input cost shares in total costs, are linear functions of parameters of the cost function (Binswanger, Baanante and Sidhu).

Finally, the elasticity of demand (η_{ik}) for input i with respect to the kth fixed factor Z_k is also obtained from (4):

$$(12)\quad \eta_{ik} = \frac{\partial \ln X_i}{\partial \ln Z_k} = \frac{\partial \ln \pi}{\partial \ln Z_k} - \frac{\partial \ln P_i}{\partial \ln Z_k} + \frac{\partial \ln}{\partial \ln Z_k}\left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(13)\quad \eta_{ik} = \sum_{i=1}^{n} \delta_{ik} \ln P_i + \beta_k - \frac{\delta_{ik}}{S^*_i}.$$

Output Supply Elasticities

Output supply elasticities with respect to output price, prices of variable inputs of production, and quantities of fixed factors, evaluated at averages of the S_i and at given levels of exogenous variables, can also be expressed as linear functions of parameters of the restricted profit function. From the duality theory (Lau and Yotopoulos 1972) the equation for output supply V can be written as

$$(14)\quad V = \pi + \sum_{i=1}^{n} P_i X_i.$$

The various supply elasticity estimates can be derived from this equation. Rewrite (14) with the help of (3) as follows:

$$(15)\quad V = \pi + \sum_{i=1}^{n} \pi \left(-\frac{\partial \ln \pi}{\partial \ln P_i}\right), \text{ or}$$

$$V = \pi\left(1 - \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(16)\quad \ln V = \ln \pi + \ln\left(1 - \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i}\right).$$

Then, the elasticity of supply (ϵ_{vi}) with respect to the price of the ith variable input is given by

$$(17)\quad \epsilon_{vi} = \frac{\partial \ln V}{\partial \ln P_i} = \frac{\partial \ln \pi}{\partial \ln P_i} + \frac{\partial \ln}{\partial \ln P_i}\left(1 - \sum_{h=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_h}\right),$$

where $i = h = 1, \ldots, n$.

And, for the translog profit function case this becomes

$$(18)\quad \epsilon_{vi} = -S^*_i - \sum_{h=1}^{n} \gamma_{hi} \Big/ \left(1 + \sum_{h=1}^{n} S^*_h\right).$$

The own-price elasticity of supply (ϵ_{vv}) is given by

$$(19)\quad \epsilon_{vv} = \frac{\partial \ln V}{\partial \ln P_y} = \frac{\partial \ln \pi}{\partial \ln P_y} + \frac{\partial \ln}{\partial \ln P_y}\left(1 - \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(20)\quad \epsilon_{vv} = \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i} \cdot \frac{\partial \ln P_i}{\partial \ln P_y} - \sum_{i=1}^{n} \sum_{h=1}^{n} \gamma_{ih} \Big/ \left(1 + \sum_{h=1}^{n} S^*_h\right),$$

$$(21)\quad \epsilon_{vv} = \sum_{i=1}^{n} S^*_i + \sum_{i=1}^{n} \sum_{h=1}^{n} \gamma_{ih} \Big/ \left(1 + \sum_{h=1}^{n} S^*_h\right).$$

And, finally, the elasticity of output supply (ϵ_{vk}) with respect to the fixed inputs Z_k is given by

$$(22)\quad \epsilon_{vk} = \frac{\partial \ln V}{\partial \ln Z_k} = \frac{\partial \ln \pi}{\partial \ln Z_k} + \frac{\partial \ln}{\partial \ln Z_k}\left(1 - \sum_{i=1}^{n} \frac{\partial \ln \pi}{\partial \ln P_i}\right),$$

$$(23)\quad \epsilon_{vk} = \sum_{i=1}^{n} \delta_{ik} \ln P_i + \beta_k - \sum_{i=1}^{n} \delta_{ik} \Big/ \left(1 + \sum_{h=1}^{n} S^*_h\right).$$

Empirical Estimation of the Model

The empirical application is now fairly straightforward. First, the model is specified in actual variables, and the variables are defined. Second, the parameters of the model are estimated using generalized least squares (GLS). Then the estimation results are presented and discussed.

Model Specification

From the general function (1), the normalized restricted translog profit function for the Indian Punjab farms producing Mexican wheat varieties (MWV) 1970–71 can be specified in actual variables as:[3]

[3] The basic farm-level data for this research pertain to Mexican wheat varieties (MWV) grown during the crop year 1970–71 in the Indian Punjab. These data were obtained from a stratified random sample spread over four different sites of the state and are thus quite representative of wheat production in the state. It should be noted that the second-order terms in the fixed inputs for which a priori technical and intuitive judgments did not support the existence of interaction are not included in the model. Out of a total of twenty-eight only sixteen second-order terms are included.

$$
\begin{aligned}
(24)\quad \ln \pi^* = {} & \alpha_o + \alpha_L \ln P^*_L + \alpha_F \ln P^*_F \\
& + \alpha_A \ln P^*_A + \tfrac{1}{2}\gamma_{LL} \ln P^*_L \ln P^*_L \\
& + \tfrac{1}{2}\gamma_{FF} \ln P^*_F \ln P^*_F \\
& + \tfrac{1}{2}\gamma_{AA} \ln P^*_A \ln P^*_A \\
& + \gamma_{LF} \ln P^*_L \ln P^*_F \\
& + \gamma_{LA} \ln P^*_L \ln P^*_A \\
& + \gamma_{FA} \ln P^*_F \ln P^*_A \\
& + \sum_{K=1}^{7} \delta_{LK} \ln P^*_L \ln Z_K \\
& + \sum_{K=1}^{7} \delta_{FK} \ln P^*_F \ln Z_K \\
& + \sum_{K=1}^{7} \delta_{AK} \ln P^*_A \ln Z_k \\
& + \sum_{K=1}^{7} \beta_K \ln Z_K \\
& + \tfrac{1}{2} \sum_{K=1}^{7} \phi_{KK} (\ln Z_K)^2 \\
& + \phi_{12} \ln Z_1 \cdot \ln Z_2 \\
& + \phi_{17} \ln Z_1 \ln Z_7 \\
& + \phi_{27} \ln Z_2 \ln Z_7 \\
& + \phi_{34} \ln Z_3 \ln Z_4 \\
& + \phi_{35} \ln Z_3 \cdot \ln Z_5 \\
& + \phi_{37} \ln Z_3 \ln Z_7 \\
& + \phi_{45} \ln Z_4 \ln Z_5 \\
& + \phi_{47} \ln Z_4 \ln Z_7 \\
& + \phi_{57} \ln Z_5 \ln Z_7,
\end{aligned}
$$

where π^* is the restricted profit from wheat production per farm: total revenue less total costs of labor, chemical fertilizer, and animal power normalized by the price of wheat; P^*_L is the money wage rate of labor per hour normalized by the price of wheat. (The money wage rate is obtained by dividing the total labor expenditure for wheat production per farm by the quantity of labor including both family and hired labor.[4]); P^*_F is the money price per kilogram of fertilizer nutrients ($N + P_2O_5 + K_2O$) normalized by the price of wheat; and P^*_A is the money price of animal power (pair of oxen) per hour normalized by the price of wheat. (The money price is obtained by dividing the total animal power expenditure for wheat production per farm by the hours of use of animal power.)

The definitions of the seven fixed inputs Z_K, included in the specification of the profit function, are as follows: Z_1 is the quantity of capital equipment and machinery used for wheat production per farm measured as rupees of annualized flow cost of total expenditures and investments on these inputs (An interest rate of 10% is used to determine the annuities.); Z_2 is the land input (land) measured as hectares of wheat grown per farm; Z_3 is the soil (pH) of the farmland under wheat production (measured as a deviation of the average—over soil samples per farm—soil pH value from an "optimum" of 6.50); Z_4 is the soil organic carbon content of land under wheat production measured as percentage (a measure of soil organic matter); Z_5 is the available P_2O_5 and K_2O (P + K) in the soil (land under wheat production) measured in pounds per acre; Z_6 is the average number of years of schooling per family member (over 13 years of age) of the farm household; and Z_7 is the area-weighted average number of irrigations per hectare applied to wheat crop.

The parameters α_o, α, γ, δ, β, and ϕ are to be estimated and subscripts L, F, and A stand for the variable inputs of production labor, chemical fertilizer, and animal power, respectively.

Following the development of (2), the S_i functions for labor, chemical fertilizer, and animal power are obtained by differentiating the normalized restricted translog profit function (24) as follows:

$$
(25)\quad -\frac{P^*_L \cdot X_L}{\pi^*} = \alpha_L + \gamma_{LL} \ln P^*_L + \gamma_{LF} \ln P^*_F + \gamma_{LA} \ln P^*_A + \sum_{k=1}^{7} \delta_{LK} \ln Z_K,
$$

$$
(26)\quad -\frac{P^*_F \cdot X_F}{\pi^*} = \alpha_F + \gamma_{FF} \ln P^*_F + \gamma_{FL} \ln P^*_L + \gamma_{FA} \ln P^*_A + \sum_{k=1}^{n} \delta_{FK} \ln Z_K,
$$

$$
(27)\quad -\frac{P^*_A \cdot X_A}{\pi^*} = \alpha_A + \gamma_{AA} \ln P^*_A + \gamma_{AL} \ln P^*_L + \gamma_{AF} \ln P^*_F + \sum_{k=1}^{n} \delta_{AK} \ln Z_K,
$$

where X_L, X_F, and X_A are the quantities of variable inputs of labor, chemical fertilizer, and animal power, respectively. Other variables, parameters, and symbols are as defined earlier.

The model consisting of the normalized restricted translog profit function (24) and the S_i functions (25), (26), and (27) is estimated

[4] The total labor expenditure per farm includes the imputed costs of family labor at the wage rate paid to permanent hired labor. Child and female labor is converted into man equivalents by treating two children (or women) equal to one man.

using the data pertaining to the MWV from the Indian Punjab.

For statistical specification additive errors with zero expectations and finite variance are assumed for each of the four equations of the model. The covariances of the errors of any two of the equations for the same farm may not be zero, but the covariances of the errors of any two equations corresponding to different farms are assumed to be identically zero. Under these assumptions, an asymptotically efficient method of estimation (Zellner) is used to estimate jointly the equations (24), (25), (26), and (27) by the application of restricted generalized least squares. In addition to the symmetry constraints ($\gamma_{LF} = \gamma_{FL}$, $\gamma_{LA} = \gamma_{AL}$, $\gamma_{FA} = \gamma_{AF}$), the linear parametric constraints required are also imposed across equations.

Empirical Results and Their Implications

Restricted parameter estimates of the normalized restricted translog profit function and S_i equations for labor, fertilizer, and animal power are presented in table 1. Before proceeding further, we report the results of two formal statistical tests. The first test is conducted for the validity of the symmetry and parametric constraints across profit and S_i equations. The null hypothesis is that parameters of the S_i equations (25), (26), and (27) are equal to the corresponding same parameters in equation (24) and that $\gamma_{FL} = \gamma_{LF}$, $\gamma_{AL} = \gamma_{LA}$ and $\gamma_{AF} = \gamma_{FA}$. This is a joint hypothesis on the validity of imposing thirty-three restrictions to estimate jointly equations (24), (25), (26), and (27). An F-test statistic with good asymptotic properties is conducted to test this hypothesis (Theil). The computed $F_{(33,213)}$ equals 1.344, and the critical $F_{0.05(33,213)}$ equals 1.52. Thus, the null hypothesis (validity of the constraints) cannot be rejected at the 0.05 level of significance. This implies, among other things, that the sample farms, on an average, maximize profits with respect to normalized prices of the variable inputs, thus supporting empirically the assumption of profit maximization.

The second statistical test is carried out to test for the Cobb-Douglas (C-D) hypothesis. It $F_{(43,246)}$ equals 3.758, and the critical $F_{0.01(43,246)}$ equals 1.45. Thus, the hypothesis is rejected, and the translog representation appears to be more suitable than the C-D for the data and model specification being analyzed. This, however, does not mean that for a different model specification and/or data set the C-D formulation could not be appropriate and analytically useful and convenient. The estimates presented in table 1 form the basis for deriving elasticity estimates for wheat supply and input demand for the variable inputs of labor, fertilizer, and animal power presented in table 2. These elasticity estimates are obtained by using equations (6), (8), (11), (13), (18), (21), and (23). As noted earlier, the elasticities are functions of variable input ratios, variable input prices, levels of fixed inputs, and the parameter estimates of the translog profit function presented in table 1. These elasticities are evaluated at simple averages of the S_i and at geometric means of the variable input prices and of levels of fixed inputs. With this assumption, the elasticity estimates become linear transformations of the parameter estimates of the translog profit function, and an asymptotic F-value can be computed to test for their significance by imposing linear constraints on the appropriate parameters of the model (Theil, Mann). These asymptotic F-values are presented in parentheses in table 2.

Estimates of wheat supply and variable input demand elasticities for labor, fertilizer, and animal power with respect to wheat price, variable input prices, and fixed inputs are valuable results in themselves, as they are a prerequisite and can be applied readily to assess the impact of a variety of micropolicy actions.

In table 2, the elasticity estimates derived from the parameters of the translog profit function are compared with those derived from the Cobb-Douglas function. In the C-D case, the impact across variable input demand functions of labor, fertilizer, and animal power of a given change in any of the exogenous variables is symmetric. This, as is well known, is due to the constant unitary elasticity of substitution among all input pairs in the case of C-D function. The impact of a similar change

Table 1. Restricted Parameter Estimates of the Translog Profit Function, MWV, the Indian Punjab, 1970–71

	Intercept	Price of Animal Power	Price of Fertilizer	Price of Labor	Capital	Land	Soil pH	Soil Organic Carbon	Soil P + K	Education	Irrigation
		$\ln P^*_A$	$\ln P^*_F$	$\ln P^*_L$	$\ln Z_1$	$\ln Z_2$	$\ln Z_3$	$\ln Z_4$	$\ln Z_5$	$\ln Z_6$	$\ln Z_7$
Labor ratio to profit	0.3981	−0.0363	0.0188	−0.3478	0.1620	−0.1819	−0.4132	0.0144	−0.0234	−0.0344	−0.1399
	(0.8011)	(0.049)	(0.089)	(0.138)	(0.062)	(0.077)	(0.226)	(0.075)	(0.090)	(0.021)	(0.118)
Fertilizer ratio to profit	−0.2132	−0.0432	0.1339	0.0188	0.0616	−0.1010	−0.1697	0.0291	0.0230	−0.0314	−0.0331
	(0.415)	(0.025)	(0.183)	(0.009)	(0.031)	(0.038)	(0.115)	(0.038)	(0.045)	(0.011)	(0.060)
Animal power ratio to profit	0.1100	−0.2290	−0.0432	−0.0363	0.2670	−0.2224	−0.4218	0.0874	−0.0696	−0.0594	0.1499
	(0.816)	(0.053)	(0.025)	(0.049)	(0.064)	(0.079)	(0.236)	(0.078)	(0.096)	(0.022)	(0.120)
Profit function	−14.642	−0.4428	−0.2132	0.3981	2.5418	−2.0367	−3.7763	1.9607	3.2549	0.0693	4.2131
	(34.696)	(1.425)	(0.725)	(1.398)	(2.371)	(2.792)	(14.389)	(4.309)	(3.511)	(0.069)	(8.201)
	$(\ln P^*_L)^2/2$	$(\ln P^*_F)^2/2$	$(\ln P^*_A)^2/2$	$\ln P^*_L \cdot \ln P^*_F$	$\ln P^*_L \cdot \ln P^*_A$	$\ln P^*_F \cdot \ln P^*_A$	$\ln P^*_L \cdot \ln Z_1$	$\ln P^*_L \cdot \ln Z_2$	$\ln P^*_L \cdot \ln Z_3$	$\ln P^*_L \cdot \ln Z_4$	$\ln P^*_L \cdot \ln Z_5$
	−0.3478	0.1339	−0.2290	0.0188	−0.0363	−0.0432	0.1620	−0.1819	−0.4132	0.0144	−0.0234
	(0.240)	(0.320)	(0.093)	(0.157)	(0.086)	(0.044)	(0.108)	(0.134)	(0.395)	(0.131)	(0.158)
	$(\ln P^*_L \cdot \ln Z_6)$	$\ln P^*_L \cdot \ln Z_7$	$\ln P^*_F \cdot \ln Z_1$	$\ln P^*_F \cdot \ln Z_2$	$\ln P^*_F \cdot \ln Z_3$	$\ln P^*_F \cdot \ln Z_4$	$\ln P^*_F \cdot \ln Z_5$	$\ln P^*_F \cdot \ln Z_6$	$\ln P^*_F \cdot \ln Z_7$	$\ln P^*_A \cdot \ln Z_1$	$\ln P^*_A \cdot \ln Z_2$
	−0.0344	−0.1399	0.0616	0.1010	−0.1697	−0.0291	0.0230	−0.0314	−0.0331	0.2670	−0.2224
	(0.038)	(0.206)	(0.054)	(0.067)	(0.201)	(0.067)	(0.078)	(0.019)	(0.105)	(0.112)	(0.139)
	$(\ln P^*_A \cdot \ln Z_3)$	$\ln P^*_A \cdot \ln Z_4$	$\ln P^*_A \cdot \ln Z_5$	$\ln P^*_A \cdot \ln Z_6$	$\ln P^*_A \cdot \ln Z_7$	$(\ln Z_1)^2/2$	$(\ln Z_2)^2/2$	$(\ln Z_3)^2/2$	$(\ln Z_4)^2/2$	$(\ln Z_5)^2/2$	$(\ln Z_6)^2/2$
	−0.4218	0.0874	−0.0696	−0.0594	0.1499	−0.4684	−0.4078	2.8811	−0.4072	−0.388	0.1235
	(0.412)	(0.137)	(0.168)	(0.038)	(0.209)	(0.436)	(0.685)	(5.07)	(0.663)	(0.627)	(0.082)
	$(\ln Z_7)^2/2$	$\ln Z_1 \cdot \ln Z_2$	$\ln Z_1 \cdot \ln Z_7$	$\ln Z_2 \cdot \ln Z_7$	$\ln Z_3 \cdot \ln Z_4$	$\ln Z_3 \cdot \ln Z_5$	$\ln Z_3 \cdot \ln Z_7$	$\ln Z_4 \cdot \ln Z_5$	$\ln Z_4 \cdot \ln Z_7$	$\ln Z_5 \cdot \ln Z_7$	
	0.3830	0.4503	−0.0455	0.2624	−0.0105	−1.7596	1.7926	0.5784	−1.3041	−0.5997	
	(2.286)	(0.527)	(0.393)	(0.512)	(1.413)	(1.464)	(2.059)	(0.491)	(0.642)	(0.763)	

Note: Asymptotic standard errors are in parentheses.

Table 2. Derived Elasticity Estimates for Wheat Supply and Demand for Variable Inputs of Wheat, the Indian Punjab, 1970–71

	Price of Wheat	Price of Labor	Price of Fertilizer	Price of Animal Power	Capital	Land	Soil pH	Organic Soil Carbon	Soil (P + K)	Education	Irrigation
Derived from Parameter Estimates of the Translog Profit Function:[a]											
Wheat supply	0.6337[b]	−0.2672[c]	−0.2513[c]	−0.1151[d]	0.1933[c]	0.6951[b]	−0.8160[c]	0.0929	−0.0324	0.0874[c]	0.5641[b]
	(7.797)	(5.462)	(4.376)	(3.078)	(3.978)	(34.550)	(4.309)	(0.836)	(0.075)	(5.269)	(12.005)
Labor	1.1269[b]	−0.6954[c]	−0.2356	−0.1958[d]	0.0932	0.8311[b]	−0.4329	0.1293	−0.0175	0.0977[c]	0.8584[b]
	(31.962)	(4.511)	(1.221)	(2.800)	(0.429)	(23.790)	(0.646)	(0.668)	(0.008)	(3.667)	(11.135)
Fertilizer	2.4895	−0.5534	−1.8829[d]	−0.0531	0.1312	0.9522[b]	−0.4649	0.0112	−0.1870	0.1838[b]	0.7223[c]
	(1.311)	(1.221)	(3.387)	(0.142)	(0.595)	(21.314)	(0.525)	(0.002)	(0.667)	(8.707)	(5.256)
Animal power	0.8060[b]	−0.3249[d]	−0.0375	−0.4434[c]	−0.5219[c]	1.2407[b]	0.1946	−0.1566	0.1840	0.2381[b]	0.0076
	(43.990)	(2.800)	(0.142)	(4.439)	(4.677)	(18.115)	(0.046)	(0.299)	(0.266)	(8.327)	(0.000)
Cobb-Douglas Case:											
Wheat supply	0.783[b]	−0.402[b]	−0.173[b]	−0.208[b]	0.297[b]	0.649[b]	−0.717[b]	0.170	0.026	−0.029	0.585[b]
Labor	1.783[b]	−1.402[b]	−0.173[b]	−0.208[b]	0.297[b]	0.649[b]	−0.717[b]	0.170	0.026	−0.029	0.585[b]
Fertilizer	1.783[b]	−0.402[b]	−0.173[b]	−0.208[b]	0.297[b]	0.649[b]	−0.717[b]	0.170	0.026	−0.029	0.585[b]
Animal power	1.783[b]	−0.402[b]	−0.173[b]	−1.208[b]	0.297[b]	0.649[b]	−0.717[b]	0.170	0.026	−0.029	0.585[b]

[a] Using equations (6), (8), (11), (13), (18), (21), and (23), and simple averages of input S_i ratios. F-values in parentheses; $F_{0.10}(1, 246) = 2.71$; $F_{0.05}(1, 246) = 3.88$.
[b] Significant at 0.01 level.
[c] Significant at 0.05 level.
[d] Significant at 0.10 level.

Their influence, however, is not uniform (as in the C-D case) on labor, fertilizer, and animal power demand functions. Expansion in farm capital, in the form of implements and machinery, for example, decreases significantly the demand for animal power, contributes positively for wheat supply, but is not significant for labor and fertilizer demands. Expansion of irrigation increases demand only for farm labor and fertilizer but not for animal power. The influence of expansion in education of the farm family is quite important. It increases demand for all variable inputs but, more importantly, for fertilizer and animal power. It also influences wheat supply significantly. Exogenous increases in land quantities also increase wheat supply and demand for all variable inputs of production. But again, the impact is not uniform. All price effects are quite reasonable and in accord with the usual hypotheses. Nonsymmetric nature of their impact, contrary to the C-D case, is as expected and more natural.

As pointed out earlier, the inclusion of soil-related, "state-of-nature" variables is rather an uncommon practice in farm economic analysis. Of the three soil characteristics (soil pH, soil organic carbon, and soil [P + K]) included in the analysis, the soil pH appears to be the most important environmental variable. It has a strong negative influence on wheat supply. It also has a nontrivial negative influence on labor and fertilizer demands.

Two Examples

A variety of policy analyses are possible by using the estimates presented in tables 1 and 2. Because fertilizer is an important purchased input in modern agricultural production, in this section we construct two examples to study the impact on fertilizer demand of exogenously (policy) determined changes in soil pH, education, and irrigation.

Soil pH is measured as a deviation of the actual pH from an assumed "optimum" of 6.5. The geometric mean of the pH deviation (from 6.5) is 1.93. The geometric mean of fertilizer use per hectare, at the geometric mean of pH deviation of 1.93 or a pH of 6.5 + 1.93 = 8.43, is 105.62 kilograms (kg.). The elasticity of fertilizer demand with respect to soil pH is −0.465 (table 2). This elasticity can be used to estimate the profit-maximizing level of use of fertilizer (N + P + K) at various pH levels holding other fixed inputs and prices of variable inputs and wheat constant. A few such configurations are presented in table 3. Thus, if average pH decreases from 8.4 to 8.0, fertilizer use will increase from 105 kg. to 115 kg. of nutrients per hectare.[5] This result also can be used to adjust recommendations for fertilizer application for MWV in the Indian Punjab. For example, in soils with a pH of 8, fertilizer use recommendation should be 10% higher than in the case of soils with a pH of 8.4, holding other things constant. It should be noted that, in general, the farm soil analysis data are used to make fertilizer recommendations for targeted crop yields and not for determining profit-maximizing levels of fertilizer use (see Singh and Sharma). To the knowledge of the authors, this is the first attempt where information on soil analysis is included in a formal farm-level input demand model.

Table 3. The Influence of Soil pH on Fertilizer Use, MWV, the Indian Punjab, 1970–71

pH	Change of pH Deviation from Geometric Mean (%)	Profit-Maximizing Level of Fertilizer Use (N + P + K) kg./ha.
8.05	−20	115.44
8.24	−10	110.53
8.43	0	105.62
8.62	+10	100.71
8.81	+20	95.80

Second, in table 4 the impact of exogenously (policy) determined changes in soil pH, irrigation, and education is presented. Each one of them individually can be increased or decreased by 10%, holding the other two constant at their geometric mean levels, and the resulting impact on fertilizer use can be compared. Similarly, one could construct information to evaluate the impact of other combinations of policy changes.

[5] It is well known that the soils in the Indian Punjab have high pH levels. This result indicates that high pH levels are a constraint to expand the role of fertilizer in increasing wheat production in the state. If further investigations, including research on crops other than wheat, support this result, there may be need for serious consideration of strengthening the ongoing soil reclamation work to lower pH levels in the Indian Punjab soils. Also, the long-run tradeoff between the effects of lowering fertilizer prices through subsidies or lowering soil pH by reclamation programs should be investigated.

Table 4. Effects of Changes in Soil pH, Irrigation, and Education on the Average Level of Fertilizer (NPK) Use in the Indian Punjab, 1970–71

Mean and Changes	Soil pH	Irrigation (Number of Irrigations)	Education (Average Number of School Years)	Average Level of Fertilizer Used (kg. of NPK/ha.)
−10% Education	8.43	7.00	1.50	103.6
−10% Irrigation	8.43	6.3	1.66	97.9
+10% Soil pH deviation	8.62	7.00	1.66	100.7
Mean	8.43	7.00	1.66	105.6
−10% Soil pH deviation	8.24	7.00	1.66	110.5
+10% Irrigation	8.43	7.70	1.66	113.2
+10% Education	8.43	7.00	1.83	107.5

Note: Effects evaluated at the geometric mean of prices of variable inputs and wheat and quantities of other fixed inputs and by using elasticity estimates of fertilizer demand with respect to soil pH deviation from "optimum," irrigation, and education. Geometric means of the variables are (*a*) soil pH deviation from "optimum" (6.5) = 193, (*b*) number of irrigations = 7.00, and (*c*) average number of school years = 1.66.

Conclusions

In this paper, the parameters of a model based on the normalized restricted translog profit function and the derived system of demand equations for variable inputs were estimated with farm-level data for Mexican wheat varieties from the Indian Punjab. In addition to the variable inputs of labor, fertilizer, and animal power and the fixed inputs of land, physical capital, and irrigation water, a few soil-related, "state-of-nature" variables measured by actual soil analysis and education were included in the model. While the empirical results for the specification employed are plausible, they also demonstrate in this case a lack of support for the hypothesis of the Cobb-Douglas form of the profit function. Of particular importance is the result that the flexibility afforded by the translog formulation allowed the exogenous variables to produce different impacts across input demand functions of labor, fertilizer, and animal power. This is much more natural as compared to the symmetric impacts produced in the case of the Cobb-Douglas formulation.

The formulation allowed a considerably more disaggregated analysis of the farm production structure than has been possible in the past. The elasticity estimates for input demands and output supply include both the price elasticities and the elasticities with respect to several other variables that are usually considered as constraints on farm production. Thus, policy analyses which evaluate the impact of changes in single price or nonprice variables or combinations of them become available.

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Nutritional Adaptations of Linear Programming for Planning Rural Development

Peter H. Calkins

Linear programming can help plan rural development if the income-maximization and least-cost diet models are integrated within the resource and management limitations of small-scale representative farms. Seven modifications adapt linear programming to subsistence households. Caveats in this context include risk, level of nutritional awareness, production scale, and result sensitivity. Through six model formulations for a representative Nepalese farm, linear programming identifies the most nutritious and profitable production patterns; trade-offs between nutrition and income; and the costs of constraints relating to levels of credit, market availability, and human capital development.

Key words: linear programming, Nepal, nutrition, rural development, subsistence farms.

The decade of the 1970s focused increasingly on holistic solutions to rural deprivation. The shibboleths of the day called for "integration," "appropriateness," and attention to the nutritional and income needs of those passed by in the biochemical revolution in crop production of the 1960s. With regard to human nutrition, linear programming has proven successful in planning least-cost menus for hospitals in developed nations (Balintfy, Stimson and Stimson, Hall). But the institutional setting of the hospital or school in a developed country is far different from the homestead of a subsistence farmer.

The farm family in a developing country must be both an efficient producer and an efficient consumer of food. If we assume the objective is to maximize the value of production subject to meeting minimal dietary requirements, a linear programming framework can be applied at the local, household level. The linear program must combine the least-cost diet model with the income maximization model and build in the resource and management limitations of small-scale farms in representative agroclimates.

Previous studies have furthered such research methodology (Mudahar, Singh, Smith, Andrews and Moore). In this paper, I first summarize specific modifications for applying linear programming to small-scale farms in subsistence economies, while pointing out the limitations of linear programming as a tool in this context. Then, I use several linear programming formulations to test the feasibility of, and measure the trade-offs between, income and nutritional objectives. Finally, I illustrate the use of linear programming to identify more nutritious, higher-income production patterns for a representative farm in the hill region of Nepal.

Modifications of Linear Programming for Application to Subsistence Farms

The nonmarket orientation of subsistence farms means that they face unique limitations in the acquisition and use of technology and the factors of production and that they cannot depend upon the market to supply their food needs. The type of linear programming model used to optimize production on a farm in a developed, capitalistic economy must be re-

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structured so that realistic and beneficial farm plans may be extended to subsistence farms. Seven modifications were developed in a study of four representative farms in Nepal (Calkins), which would apply to most subsistence contexts.

First, in addition to production, feeding, milling, selling, and input purchase activities, activities that portray processing, storage, purchase and consumption of fresh or preserved foodstuffs must be included (table 1). These permit the family to retain foods for home consumption and to spread their intake of nutrients over the year. An appropriate loss in nutrients should be included to reflect the effects of cooking, drying, or fermentation. Whenever a commodity can be either sold or consumed by the household, the model must contain both selling and consumption activities so that the solution will determine the optimal quantities to be devoted to each use. Radishes and paddy rice in table 1 are examples.

Second, nutritional constraints representing the aggregate family demand for each nutrient in each season (e.g., monsoon protein, winter niacin) should be included in the rows of the matrix at greater than or equal to minimum levels. The example in this paper includes nine types of nutrient constraints in each of three seasons, yielding twenty-seven matrix rows in all. Required levels may be taken from the recommended daily intakes for various sex and age groups (FAO). For example, the average daily requirements for a prime-age, adult male were 2,625 calories, 48 milligrams (mg.) protein, 450 mg. calcium, 18 mg. iron, 1,500 mg. carotene, 9 mg. thiamine, 1.35 mg. riboflavin, 14.7 mg. niacin, and 30 mg. ascorbic acid. For protein requirements in particular, the weight of each family member should be multiplied by the factors implicit in the FAO computations for "seemingly well-nourished" individuals. In this paper, no attempt will be made to take account of the quality of protein consumed, though this may be included through nonlinear formulations (Smith). Aykroyd is a good source of information about caloric requirements: for major age-sex groups over the age of fifteen, he gives basic metabolic and energy expenditure totals for different types of work. Labor records must then be consulted to determine the percentage of sedentary, moderate (e.g., cooking, walking, and harvesting grain), and heavy (e.g., carrying loads, woodchopping, and plowing) work performed by each sex-age group. Adjustments for different basic metabolic needs due to temperature changes should also be reflected in the figures for seasonal caloric requirements.

Third, constraints may have to be added to reflect the tastes and preferences of the local population. Sweet potatoes may be a rich source of β-carotene, but if the family refuses to eat any more than ten kilograms per month of this food, a less than or equal to constraint should be included. Similarly, there are physiological barriers to eating too much of a given foodstuff; it would be unrealistic to hope that a

Table 1. Partial Linear Programming Matrix Adapted for Human Nutrition on Farms in Developing Countries

	Grow Paddy	Grow Radish	Raise Cows	Hire Labor	Mill Paddy	Eat Rice	Sell Paddy	Ferment Greens	Eat Radish	Eat Garlic	Graze	Row Type
Income over consumption	−	−	−	−	−		+					N
Land	+	+										L
Labor	+	+	+	−	+		+	+			−	L
Manure	+	+	−									L
Paddy	−				+		−					L
Rice					−	+						L
Paddy straw	−		+									L
Radish		−							+			L
Radish greens		−						+				L
Calories						+		+	+	+		G
Ascorbic acid								+	+	+		G
Paddy area	+											G
Max. garlic consumption										+		L
Herd size			+									E
Grazing transfer			−								+	L

Note: "+" indicates a positive matrix element coefficient; "−" indicates a negative matrix element coefficient; blank indicates no entry.

family could depend upon garlic as its major source of protein, for example. Thus, the "optimal" solutions for meeting the consumption demands most efficiently will not necessarily provide acceptable diets for the family. These "structural and variety requirements" are noted by Balintfy.

Fourth, the maximand must be changed from the simple "net farm income" of the standard linear program to "net farm income over consumption." Because of the changes listed above, the maximand now reflects not just the gross value of produce less the cost of purchased inputs and operating capital, but also the retention of part or all of the produce for home consumption and/or the purchase of food from the market to meet nutritional requirements.

Fifth, special attention should be given to computing the supply and productivity of labor, the most abundant resource on most subsistence farms. Careful observation of common tasks performed by each member of the family yields a coefficient of comparative productivity, which should be multiplied by the total number of hours per day that person has available for agronomic and livestock production. Where livestock grazing is a significant activity on the farm, a grazing externality activity should also be included to reflect the labor saved by herding more animals. As each animal is added, average labor requirements per head in the farm plan are reduced by an appropriate amount in the months in which the animals are herded.

Sixth, because of the malnourishment or even death which may attend crop failure, land allocation constraints should be included in some formulations to reflect the traditional allocation of land to broad classes of crops, like grains and legumes, which has allowed the farmer's forebears to survive in the area. Land purchase or rental activities should be included only after careful consideration of local conditions.

Finally, traditional production techniques should be adhered to, at least in the initial formulation of the model. The use of chemical fertilizers, pesticides, and other improved technology may not be suitable to the subsistence farmer's resources, risk-bearing ability, or level of management.

Alternative Formulations

In developing a farm model for use in generating income and nutritional policy recommendations for a wide number of farms, the linear program should be systematically modified to determine the sensitivity of the optimal solution to different policy measures and goals of the farm operator. For instance, the prices included in the maximand row, and the type or level of constraint as indicated in the right-hand sides may be varied, as well as the type and number of activities included in the matrix. The following six formulations were used by the writer (Calkins):

(*a*) the simple short run (allowing for adjustments that can be made within two cropping seasons) with no nutritional constraints;

(*b*) the short run with nutritional constraints and unlimited use of the market to meet consumption demands, i.e., the family may purchase food from the market place and sell surplus production;

(*c*) the short run with nutritional constraints and marketing limited by a ceiling on capital borrowing—this formulation both highlights the trade-off between income and nutrition and induces home labor to be more productive, as there are limited funds to hire outside labor;

(*d*) the short run with nutritional constraints and no food buying—this formulation shows the trade-off between income and nutrition when all food consumed on the farm must also be produced there;

(*e*) the short run with nutritional constraints plus the assumption that 75% of acreage must be planted to cereal and leguminous crops—this formulation reflects the opportunity cost, if any, of traditional cropping patterns; and

(*f*) the long run, a period ten years hence, including projected price relationships and allowing for changes in levels of livestock and fruit tree production—this gives an idea of the ways in which the production of given commodities may become or remain profitable or nutritious over time, and why.

One caveat with regard to the use of linear programming is its inability to treat risk. By assuming perfect knowledge of market prices and yields—with no account of how each varies separately over time, or how they work together to produce variable total revenues—linear programming tends to predict optimal combinations which may in fact be risky. The best way to overcome this problem is to reformulate the model as a quadratic program with the variance in returns as the objective function to be minimized and a target income as a parameterized constraint. Unfortunately,

in developing countries adequate time-series data are not available, while cross-sectional variances would ignore interannual price patterns. The 75% acreage constraint to grain and legumes, whose yields are fairly stable, is an alternative (if mechanistic) way of reflecting risk aversion.

A second caveat regards the assumption that subsistence families are aware of and wish to optimize their nutritional statuses. Linear programming can only suggest what optimal changes in the diet might be. Therefore, the optimal results must be attended by nutritional extension programs before they can be fully realized.

A third caveat regards expanding acreages to activities currently engaged in on a small scale. Not only does the traditional problem of linearity distort the programming of biological systems; there is also the heroic assumption that measurements of planted area, inputs, and output from, say, three tomato plants are sufficiently accurate to reflect production conditions on a per hectare basis.

A fourth caveat is that programming results may be sensitive to slight variations in resource levels, prices used, and the choice of maximum or minimum consumption levels and area constraints. Two approaches may be taken to improve result applicability. The first is to make sure that the farm selected is as representative as possible of its group for policy purposes. The farm in this paper is one of four chosen on the basis of a survey of 600 households to represent discrete microclimates and resource levels. Case studies were used rather than synthetic composite farms because of the dangers inherent in averaging resource availabilities and other structural parameters. The second approach is to perform sensitivity analysis to determine the range over which the results are applicable to a given farm.

The six institutional formulations to be presented do allow policy analysts to identify barriers that prevent households from taking advantage of crop and livestock production combinations which could increase nutritional adequacy and improve income. Given the caveats noted, such an identification of barriers may be of greater prescriptive usefulness than specific behavioral recommendations to individual farm operators.

Programming Formulations

In this section of the paper, I will illustrate the use of linear programming to identify more nutritious, higher-income production patterns for a representative farm in the hill region of Nepal.

A Sample Farm from the Nepalese Hills

To exemplify each of the six formulations, let us consider Masino Tamang (assumed name), whose homestead lies at 1,992 meters in a temperate-zone village in Nepal (Calkins, pp. 124–74). Masino has a total of 0.1526 hectares of irrigated lowland, 0.2910 hectares of unirrigated upland, and the following brood animals: 1 cow, 2 milk buffaloes, 4 ewes, and 2 hens. He is 62 years old and lives with his 52-year-old wife, his two daughters of 13 and 11 years, and his son of 5 years.

The current nutrient balance for the family in the early and monsoon seasons is fairly good, with a 40% riboflavin shortfall the only deficiency in the former and 8% calcium and 14% riboflavin deficiencies in the latter. In the winter season of two months, five of nine nutritional elements are deficient: riboflavin (by 58%), β-carotene (48%), ascorbic acid (12%), niacin (11%), and calories (4%). Riboflavin deficiency, present in all three seasons, can result in dry skin, inflamed corneas, and general debility. Only this deficiency is serious, because β-carotene, which is consumed in excess in the other two seasons, can be stored in the body's fat for much longer than two months.

Current production patterns. The following are the percentages of available land grown to each commodity for each type of land in each season (early, monsoon, winter) under Masino's current cropping patterns:

Early Lowland (14 Nov.–14 June)	(%)
Wheat	8.3
Fallow	91.7
Monsoon Lowland (15 June-14 Nov.)	
Paddy	100
Early Upland (15 Feb.–14 Aug.)	
Maize	68.9
Potato	1.5
Soybeans	0.7
Green beans	0.9
Pumpkin	0.2
Yams	0.2
Chayote	0.4
Bitter gourd	0.4
Green amaranthus	0.5
Red amaranthus	0.5
Chili	0.1

Early Upland continued	(%)
Mustard	4.4
Taro	8.7
Permanent crops	12.6
Monsoon Upland (15 Aug.–14 Dec.)	
Millet	17.6
Monsoon potato	8.7
Soybean	0.7
Pumpkin	0.2
Yams	0.2
Radish	32.4
Rape	0.4
Chayote	0.4
Bitter gourd	0.4
Chili	0.1
Mustard	17.6
Taro	8.7
Permanent crops	12.6
Winter Upland (15 Dec.–14 Feb.)	
Chayote	0.4
Chili	0.1
Mustard	4.4
Rape	0.4
Taro	8.7
Permanent crops	12.6
Fallow	73.4
Permanent Crops	
Mango	2.6
Peach	8.7
Bamboo	1.3
Net Income	
Rupees (Rs.)	3,580

Net income represents the total market value, before consumption, of all livestock and agronomic production for the year, less the costs of hiring labor and bullocks. The main double-cropping patterns are wheat followed by paddy in the lowland and monsoon millet transplanted into a standing early maize crop in the upland, with various horticultural crops occupying upland for from one to three consecutive seasons. Paddy and wheat are traditionally the only crops grown in the lowland, because it is a full hour's walk to many lowland fields from Masino's homestead.

Formulation One: The Simple Short Run

The simple short-run formulation stipulates that (*a*) permanent crop acreages and livestock levels are fixed, (*b*) food buying and selling activities are allowed, (*c*) there are no changes in technology, (*d*) there is no limit to capital borrowing, and (*e*) Masino Tamang only wishes to maximize the sale value of his product after production costs have been deducted. The following optimal land-use pattern emerges from linear programming:

Early Lowland	(%)
Wheat	100
Monsoon Lowland	
Paddy	100
Early Upland	
Potato	88.7
Permanent Crops	11.3
Monsoon Upland	
Rape	88.7
Permanent Crops	11.3
Winter Upland	
Rape	88.7
Permanent Crops	11.3
Net Income	
Rupees (Rs.)	14,926

One hundred percent of available irrigated land should be devoted to the wheat-paddy rotation. On unirrigated upland, on the other hand, potato and rape greens should be grown at the maximum permissible level. As upland constitutes about two-thirds of all land on the farm, this result shows a significant shift from grain to horticultural predominance to maximize income.

Formulation Two: The Short-run Optimal Solution with Nutritional Constraints and Unlimited Borrowing

We now expand the matrix to include nutrient constraints, which are varied from 0% to 150% of suggested FAO levels to measure the impact on cropping patterns, hiring, selling, feeding, consumption practices, and the level of income. The unbroken line in figure 1 shows that income over consumption declines from Rs. (Rupees) 14,925 to Rs. 11,253, reflecting up to a Rs. 3,672 "grocery bill" for adding 150% of the family's requirements over the eat-nothing, simple short-run, optimal formulation.[1]

At the 100% level of nutritional adequacy, a Rs. 2,375 grocery bill is used to buy 972 kilograms (kg.) of soybeans, 218 kg. of radish, 35 kg. of yams, 153 kg. of pumpkins, 53 kg. of mustard greens, and 1.8 baskets of peaches to meet nine nutritional requirements in three seasons. Optimal cropping patterns, labor and

[1] The lines in figure 1 for formulations two and three resemble curves only because they connect program values from individual linear programming formulations. They are not to suggest that nonlinear programming was used.

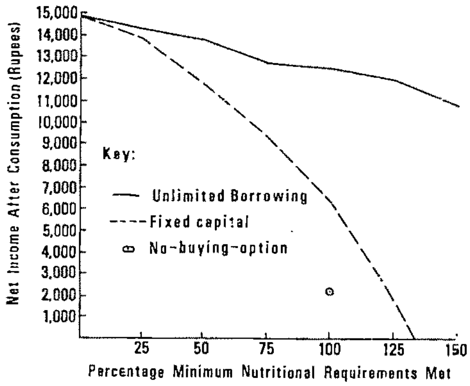

Figure 1. The trade-off between income and nutrition under unlimited borrowing, fixed capital, and no-buying-option formulations

bullock hiring. and livestock feeding activities do not change from those in formulation one. The only products previously sold but now retained are winter milk and early season peaches. This suggests that these are the cheapest sources of riboflavin and β-carotene, respectively, for these two seasons.

Formulation Three: The Short-run Optimal Solution with Nutritional Constraints and Fixed Capital

The cash with which Masino buys supplemental food for his family is limited. Formulation three parameterizes nutritional requirements subject to the constraint that Masino may borrow no more capital than 771 rupees needed in the simple income-maximizing solution. With each 25% increment in nutritional requirements, farm activities are forced in the direction of more nutritious but perhaps less profitable crops. The broken line in figure 1 represents this trade-off.

By the 100% level, the following pattern becomes optimal:

Early Lowland	(%)
Wheat	100
Monsoon Lowland	
Paddy	100
Early Upland	
Maize	38.8
Potato	49.9
Permanent crops	11.3
Monsoon Upland	
Millet	38.8
Radish	3.7
Rape	46.3
Permanent crops	11.3
Winter Upland	
Rape	46.3
Permanent crops	11.3
Fallow	32.7
Net Income Over Consumption	
Rs.	6,300

The most striking change that has occurred over formulation two is that early potato and monsoon rape production has been drastically reduced in favor of the maize-millet rotation. This shift reflects the fact that calories in all seasons (in addition to riboflavin) are nutritionally binding. Radish is also important enough to displace some of the rape on monsoon upland. This change occurs both because of the lack of capital to buy radishes and because with every hectare of radishes come a corresponding amount of nutrient-rich radish greens.

As to the trade-off between consumption and sales, paddy is earmarked for home use in the monsoon and winter, while millet, maize, and potatoes are grown to satisfy early season energy needs. All meat and fruit are now reserved for farm consumption. In addition, milk sales virtually disappear because of niacin and riboflavin needs, while millet supplies the necessary calcium in the early season. The only food which continues to be bought is soybeans, demonstrating what a valuable source of nutrients this grain legume is.

The restriction on capital not only means that farm output must be more nutritious, it also causes a shift from hired labor to labor-saving crops which can be grown by home labor. Seasonal redundancy of family labor is reduced.

Formulations one and two have demonstrated that the linear program can sort out the least-cost source of nutrients even when there is no effect upon the optimal production and input-hiring pattern, while formulation three has shown the ability of the model to develop production and consumption recommendations simultaneously.

Formulation Four: The Short-run Optimal Solution with Nutritional Constraints and No Food Buying

To reveal the trade-off between higher nutritional demands and on-farm production in its most extreme form, we may develop a forced self-sufficiency formulation, whereby Masino must meet 100% of his family's nutritional re-

quirements with no market purchase.[2] The following land-use pattern becomes optimal:

Early Lowland	(%)
Wheat	100
Monsoon Lowland	
Paddy	100
Early Upland	
Maize	53.4
Potato	35.3
Permanent crops	11.3
Monsoon Upland	
Millet	53.4
Radish	4.8
Rape	30.5
Permanent crops	11.3
Winter Upland	
Rape	30.5
Permanent crops	11.3
Fallow	58.2
Net Income over Consumption	
Rs.	2,092

This cropping pattern (and diet), represented by a circled point in figure 1, is much closer to traditional ones because of the predominant maize-millet rotation. The drawback is that income over consumption plummets from Rs. 12,479 to Rs. 2,092, indicating a strong trade-off between levels of income and nutrition if everything consumed on the farm must also be grown there.

As might be expected from current dietary deficiencies, the shadow prices under formulation four are highest for riboflavin in the early (Rs. 263 per mg.), monsoon (Rs. 66), and winter (Rs. 33) seasons, followed by monsoon and winter niacin (Rs. 1.1 and .06, respectively). Early monsoon and winter calories have shadow prices of Rs. .90, .60, and .30, respectively. That the above constraints are binding implies that cropping patterns in the no-buying-option formulation have had to be rearranged in favor of home-grown crops rich in these nutrients. Specifically, area grown to low-return maize and millet has been increased to relax the caloric and niacin constraints, while area grown to radish roots and greens has been increased to relax the riboflavin and niacin constraints.

[2] This stipulation means that one may generalize the results to all farmers of the temperate zone without fear of causing supply and demand distortions. One must, of course, assume that selling prices for produce remain at their present farmgate level and that such produce will be purchased from the farmer by middlemen for sale elsewhere.

Formulation Five: The Short-run Optimal Solution with Nutrition and Cropping Pattern Constraints

Formulation five posits that in meeting 100% of his nutritional demand with buying options and unlimited capital borrowing, Masino must follow the general practice of hill farmers: to devote about 75% of his upland to grain and legume crops. The following land-use system becomes optimal:

Early Lowland	(%)
Wheat	100
Monsoon Lowland	
Paddy	100
Early Upland	
Maize	68.9
Soybean	6.1
Potato	13.7
Permanent crops	11.3
Monsoon Upland	
Millet	68.9
Soybean	6.1
Rape	13.7
Permanent crops	11.3
Winter Upland	
Rape	13.7
Permanent crops	11.3
Fallow	75.0
Net Income over Consumption	
Rs.	2,370

There is a large opportunity cost associated with forcing maize-millet and soybean into the cropping pattern in accordance with traditional land use. This may be measured in terms of the difference in income over consumption (Rs. 10,109) between formulations two (Rs. 12,479) and five (Rs. 2,370) at the 100% level of nutrition.

Formulation Six: The Long Run

The final formulation allows livestock numbers and permanent crop areas to vary and employs projected input and output prices for the ensuing ten years. The solution for Masino's farm indicates that milk cow specialization within livestock, grain specialization on irrigated lowland, vegetable specialization on irrigated upland, and no fruit trees constitute the optimal use of land and other resources on temperate zone farms like Masino's in the longer term.

Sensitivity analysis of the prices of output and purchased inputs shows production patterns to be stable. However, varying purchased food prices induced great variation in optimal diet. These results suggest a possible policy of controlling relative prices to consumers in the marketplace.

Conclusion

The application of linear programming to a subsistence Nepalese farm has shown that large gains in income accrue from growing increased areas to potatoes, radishes, and rape on upland fields, depending upon the availability of capital and the flexibility of traditional cropping preferences. The cheapest sources of a full range of nutrients are also horticultural, including soybeans, radish, yam, pumpkin, mustard greens, and peaches. Only if the buying power of such commodities is reduced does maize-millet production for home consumption come into the optimal solution or products from the fixed activities, milk, meat, and fruit production figure in on-farm consumption.

Through different model formulations, linear programming can identify clearly the most nutritious and profitable production patterns. Moreover, formulations three through six reflect different types of institutional constraints involving, respectively, credit, market development, extension and education to alter traditional beliefs and strengthen human capital, and long-run price policies. These and other possible formulations permit the policy analyst to infer the direction of change in optimal patterns under various policy choices.

Microlevel studies of linear programming cannot solve nutritional and income problems in a vacuum, however, and must be supported by a commitment of research and extension resources. In Nepal, for example, horticultural crops are much more subject to price variability and marketing losses than grain crops. Government policies to improve marketing mechanisms and foster producer cooperatives would reduce the riskiness of horticultural production, which is now the main barrier that prevents farmers from realizing the benefits of growing these crops. Research should be geared to improving varieties of, and reducing pests in, those commodities with the greatest potential for increasing the nutrition and income levels of the rural population.

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Notes

Income and Expenditure for Relatively More versus Relatively Less Nutritious Food over the Life Cycle

Laura Blanciforti, Richard Green, and Sylvia Lane

United States consumers have been accused of being nutritionally inefficient, having a poor quality diet, and often placing themselves at nutritional risk because of their poor choice of foods (U.S. Congress). Unfortunately, the controversy over the consumption of nutritious versus less nutritious or "junk" foods has generated heated discussion but relatively little economic research.

Numerous studies have been made of the income elasticities of food consumption (Burk 1962, Hymans and Shapiro), and Engel curves derived from econometric analysis of family budgets, primarily relating expenditures on food or another consumption good or commodity group to income levels of households, *ceteris paribus,* abound in the literature (Burk 1968, pp. 84, 215; Aitchison and Brown; Allen; Allen and Bowley; Champernowne; Cramer; Goreux; Hassan and Johnson 1977; Houthakker 1952, 1957; Prais and Houthakker; Phlips; and Tornquist). Adrian and Daniel in their 1976 article investigated the consumption of selected food nutrients in the United States using income and the life cycle stage as variables in their analysis, but they did not identify the foods which were the sources of the nutrients. Few researchers have examined the implications of and the differences in food expenditure patterns of households at various points in their lifetimes. And, more important, no research has been done on the expenditures on and income elasticities of the specific groups of food classified as relatively more nutritious and less nutritious components of diets.

The specific purposes of this analysis were to ascertain, using a general functional form, whether or not expenditures on foods classified as relatively more nutritious and less nutritious components of diets vary over the life cycle for U.S. households with different income levels, and to compare income elasticities for the various life cycle stages for all foods, relatively more and relatively less nutritious components of diets.

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Description of Data

Cross-sectional data, obtained from the diary component of the second year of the 1972–1973 Consumer Expenditure Survey conducted by the Bureau of Labor Statistics, were used. Results of the 1973 Diary Survey were substantially better than those for the 1972 survey (Walsh). The sample from the 1973–74 portion of the survey totaled 10,514 observations (Carlson). The under $2,000 income group, 7.6% of the total sample and the over $35,000 group, 2% of the entire sample, were removed because their income was not recorded in actual dollar amounts. The exclusion of the over $35,000 group acted to offset partially the bias introduced by the exclusion of the under $2,000 group. Editing the data to remove observations incomplete for key variables results in 9,464 usable observations.

Income data collected was for each household's before-tax-income from all sources.[1] Expenditure data are recorded food-at-home expenditures for specific items. The data on food expenditures were grouped into three groups: total food at home, relatively more nutritious components of diets, and relatively less nutritious components of diets. The classification of foods into relatively more nutritious and less nutritious components of diets was based upon an analysis of the nutritive composition of the food items. The index of nutritional quality tables developed by Canolty of the Department of Nutrition of the University of California, Davis, were used for this purpose. To be termed "nutritious" (relatively more nutritious), a food had to contain percentages of the requirement for four or more nutrients equal to or greater than the proportion of the energy (calories) provided by that food, or the percentage required of two or more nutrients in twice the proportion to the energy contribution for that food (see table 1). This definition of nutritious is a recommended definition consistent with results from a 1976 study by the Society for Nutri-

[1] It is well known that the income variable as reported in household survey data has several deficiencies as an argument for Engel Curve estimation. For further explanation of this problem, see Brown and Deaton, p. 1172, and Hassan and Johnson 1976, pp. 5–6.

Table 1. Relatively More Nutritious and Less Nutritious Foods

Relatively More Nutritious Foods	Relatively Less Nutritious Foods
Cereals, flour, rice, pasta	Fresh cakes and cupcakes
Bread, biscuits, rolls, muffins	Cookies
	Crackers
Meats, poultry, fish and eggs (except bacon and frankfurters)	Sweet rolls, coffecakes, doughnuts
	Frozen and refrigerated bakery products, pies, tarts, turnovers
Dairy products (except ice cream and related products)	Bacon
	Frankfurters
Fruits and vegetables (except apples)	Ice cream and related products
Margarine[a]	Apples
Peanut butter	Sugar, candy, chewing gum and other sweets
Other prepared foods (except other condiments)	Other fats, oils and salad dressings
	Nondairy substitutes
	Nonalcoholic beverages
	Other condiments

[a] Butter is included in dairy products.

tion Education conducted for the Federal Trade Commission (Society for Nutrition Education).[2] The eight key nutrients used in the analysis were folacin, vitamin B-6, pantothenic acid, magnesium, vitamin A, calcium, iron, and vitamin E.[3]

Data for all households and the households stratified according to life cycle stages were used in the analysis. Since cross-sectional data are used the life cycle stages depict different families at each stage rather than a cohort of families moving through different stages. Life cycle stages in this analysis only provide a classification scheme.

The life cycle stages were:

Life cycle stage 0: all not included in groups one through six, i.e., single men, single women, etc.

Life cycle stage 1: no children are present and the housewife is 40 years of age or less.

Life cycle stage 2: average age of children is less than six years.

Life cycle stage 3: average age of children is between six and 12 years.

Life cycle stage 4: average age of children is between 12 and 17 years.

Life cycle stage 5: average age of children is over 17 years.

Life cycle stage 6: no children are present and the housewife is over 40 years age.

Because household size and composition account for a significant proportion of variation in food expenditure patterns across similar families, the income and expenditure data were adjusted separately, using an adult-equivalent scale, before estimating the Engel function.[4] The adult-equivalent scale is simply a device for specifying the requirements or expenditures of an individual of a particular age and sex as a proportion of the standard or base individual such as an adult male. The adjustment of the food expenditure and income variables makes the estimation of one Engel function for households of varying sizes, ages, and compositions possible. The procedure prevents attributing to income or food expenditures part of the variation properly attributable to variations in the age, sex of household members, or the effects of family size. Engel curves were estimated for sample households stratified according to their stage in the life cycle.

Methodology

Economic theory provides no a priori rationale for the appropriate functional form for the Engel relationship, although it does indicate that the functional form selected should obey the "adding-up" criterion (Salathe, p. 11). Yet the choice of functional form can influence substantially the estimated income elasticity. The linear and double-logarithmic tend to be the most commonly used functional forms, but empirical studies indicate the income elasticity of food is below unity and falls as income rises. This implies that both the linear functional form with rising elasticity and the double-logarithmic form with constant elasticity are inappropriate for the analysis of Engel relationships (Zarembka).

In this study Engel relationships were estimated using a Box-Cox transformation, for which the linear and logarithmic forms are special cases (Box-Cox, Chang, Zarembka).[5] To begin this anal-

[2] In that study a sample of SNE members were surveyed concerning the correct definition of a "nutritious" food so that recommendations could be made regarding a proposed Federal Trade Commission Trade Regulation Rule on the use of the term "nutritious" in food advertising.

[3] Pennington in her "Dietary Nutrient Guide" defined the first seven nutrients as key nutrients whose presence in sufficient amounts are indicators of the adequacy of a larger group of essential nutrients. She states that if one obtains the suggested daily intake of the index nutrients from natural foods and follows a few other suggestions, then the diet will be adequate in approximately all essential nutrients. Inclusion of adequate amounts of vitamin A and folacin will contribute to the vitamin E requirement but will not ensure it. The authors, thus, felt justified in including vitamin E as an index nutrient.

[4] Index values for food equivalent scales are from, Price *et al.*, vol. 2, chap. 9, p. 51. Estimates were developed by Price from the USDA 1965 Household Food Consumption Survey. For the analysis, further adjustments were made to reflect economies of size resulting from additional children as discussed in Price, p. 229, table 1. See Price for additional explanation and discussion. For explanation of derivation of income index values see USDL.

[5] When $\lambda = 1$, equation (1) is linear and when $\lambda = 0$, equation (1) is double logarithmic. In the linear case, $\lambda = 1$, and the income elasticity,

ysis the general functional form of the Engel Curve is written:

$$(1) \qquad C_i^{(\lambda)} = a_0 + a_1 Y_i^{(\lambda)} + U_i,$$

where C_i is the amount of food expenditure per food-adult equivalent, Y_i is income per income-adult equivalent, and U_i is the disturbance term of the cross-sectional group or household. The variables $C_i^{(\lambda)}$ and $Y_i^{(\lambda)}$ are defined as:

$$(2) \qquad C_i^{(\lambda)} = (C_i^{\lambda} - 1)/\lambda, \text{ and} \quad Y_i^{(\lambda)} = (Y_i^{\lambda} - 1)/\lambda,$$

where λ represents a transformation parameter to be determined. The U_i term for the given λ's is assumed to be normally and independently distributed with zero mean, constant variance, and zero covariance. The income elasticity of food demand, N_y, can be shown to be

$$(3) \qquad N_y = a_i(Y_i/C_i)^{\lambda}.$$

The sign of the income elasticity depends on the sign of a_i, since Y_i and C_i are nonnegative values but its value depends on the relationship of Y_i to C_i and the value of λ.

Given the above assumptions for U_i and using the Box-Cox maximum likelihood approach, the logarithm of the likelihood function for a given λ that is to be maximized is, disregarding the constant,

$$(4) \; L_{\max}(\lambda) = -\frac{N}{2} \ln \hat{\sigma}^2(\lambda) + (\lambda - 1) \sum_i \ln C_i,$$

where $\hat{\sigma}^2$ is the estimated error variance of the regression of $C_i^{(\lambda)}$ on $Y_i^{(\lambda)}$. Maximization of (4) over the entire parameter space requires selection of alternative values of λ over a reasonable range, the regression of $C_i^{(\lambda)}$ on $Y_i^{(\lambda)}$ and the determination of the transformation parameter $\hat{\lambda}$ that maximizes (4). An approximate $(1 - \alpha)$ confidence interval for λ can be defined since $2[L_{\max}(\hat{\lambda}) - L_{\max}(\lambda)]$ is approximately distributed as χ^2 with one degree of freedom. That is, the $(1 - \alpha)$ confidence interval for λ is obtained by finding that value on either size of $\hat{\lambda}$ such that $L_{\max}(\hat{\lambda}) - L^{\max}(\lambda) = \frac{1}{2}\chi_1^2(\alpha)$.

C_i was further subdivided into foods that are relatively more nutritious and foods that are relatively less nutritious components of diets, so three general equations were estimated. Households also were separated into life cycle groups. Average income and expenditure on all food and relatively more or less nutritious components of diets appear in table 2. Average household income, it appears, is higher

Table 2. Average Annual Household Income and Expenditure on All Food and Relatively More or Less Nutritious Foods at Each Stage of the Life Cycle

Lifecycle Stage	Income	All Food	Relatively More Nutritious food	Relatively Less Nutritious Food
	($)			
0	5,603.96	1,207.92	1,037.68	170.24
1	12,610.41	2,025.05	1,740.28	284.77
2	11,369.67	2,885.97	2,478.17	407.80
3	12,901.33	3,743.19	3,178.67	564.52
4	14,002.51	4,099.24	3,511.75	587.49
5	14,716.19	3,461.66	2,958.41	503.25
6	10,551.08	2,570.11	2,203.64	366.47
All	11,316.97	2,772.01	2,372.26	399.75

for each succeeding stage in the life cycle, excepting stage two, until stage five is reached. It then declines. Average expenditure on all food and relatively more and less nutritious food increases until stage four is reached and then declines. Food expenditure, apparently, increases with the addition of children to the household and continues to increase as the children grow older, peaking when they are teenagers.

Results

Both expenditure and income per adult equivalent were transformed as indicated in equation (2) by λ's valued at intervals of 0.01 between -1.00 and 1.00. $C_i^{(\lambda)}$ was then regressed on $Y_i^{(\lambda)}$ for each set of the transformed data. $L_{\max}(\lambda)$ was calculated for each regression by using equation (4). Estimated coefficients and related statistics for the various regressions are given in table 3. R^2 values are all very low. This is not unusual in cross-sectional studies. The maximum likelihood estimates for λ, $\hat{\lambda}$ ranged from .16 to .47, which is distinctly different from zero or one. The 95% confidence interval for each $\hat{\lambda}$ varied approximately .02 to .08 from the maximum likelihood estimates for λ, $\hat{\lambda}$. Neither $\lambda = 1$ nor $\lambda = 0$ fell within the 95% confidence interval. The null hypothesis that the functional form was linear (H_0:$\lambda = 1$) or logarithmic (H_0:$\lambda = 0$) could be rejected at the 5% level of significance. Coefficients of $Y_i^{(\lambda)}$ in all equations excepting life cycle stages 0 and 1 were significant at the 5% level.

The general functional form was considered to be a more accurate representation of the Engel curve. Income elasticities for the general functional form were represented by $N_y = a_i\left(\frac{Y_i}{C_i}\right)^{\lambda}$ and were also considered to be better estimates of income elasticities. Table 3 contains the estimates of the income elasticity at the means for all six life cycle stages for all food, and relatively more and less

$$N_y = a_i \frac{Y_i}{C_i} = \left(\frac{a_0}{a_i Y_i} - \frac{1}{Y_i} + \frac{U_i}{a_i Y_i} + \frac{1}{a_i Y_i} + 1 \right) - 1,$$

tends toward one as Y_i increases; in the log case, $\lambda = 0$, and $N_y = a_1$, the standard constant elasticity result. The semilog, hyperbolic, and log-reciprocal forms also can be shown to be special cases of the general form.

Table 3. Regression Results from the General Functional Form for All Food, Relatively More Nutritious, and Less Nutritious Food over Stages of the Life Cycle

	All Food per Adult Equivalent					Relatively More Nutritious Food per Adult Equivalent					Relatively Less Nutritious Food per Adult Equivalent				
Stages	λ	a_0	a_1	L_{max} (λ)[a]	Income Elasticity[cde]	λ	a_1	a_1	L_{max} (λ)	Income Elasticity[cde]	λ	a_1	a_1	L_{max} (λ)	Income Elasticity[cde]
All	.36	28.58	.041	−59388.33	.050	.32	21.57	.039	−57152.47	.048	.26	9.00	.037	−40455.05	.049
		(82.30)[b]	(6.66)				(77.34)	(6.23)				(54.71)	(7.03)		
0	.34	28.22	−.007	−11820.17	−.009	.31	22.64	−.009	−11203.29	−.011	.16	8.07	−.021	−7388.06	−.025
		(31.84)	(−0.44)				(30.43)	(−0.55)				(21.96)	(1.09)		
1	.34	27.26	.004	−4648.28	.005	.31	22.25	−.011	4491.22	−.013	.24	8.68	.019	−3135.31	.025
		(21.17)	(0.16)				(20.25)	(−0.43)				(13.54)	(0.86)		
2	.30	20.71	.055	−9147.38	.063	.25	15.37	.051	−8827.69	.058	.29	8.89	.051	−6340.94	.071
		(29.41)	(2.82)				(27.45)	(2.52)				(18.74)	(3.70)		
3	.41	36.77	.037	−8067.96	.046	.34	23.71	.029	7784.57	.036	.34	10.95	.046	05672.31	.071
		(32.67)	(2.32)				(30.89)	(1.77)				(21.23)	(4.12)		
4	.45	41.22	.076	−7280.51	.101	.38	26.29	.073	−7044.49	.094	.43	14.39	.038	−5085.81	.074
		(28.70)	(4.98)				(26.95)	(4.54)				(20.24)	(4.47)		
5	.47	47.19	.058	−6669.21	.083	.43	34.43	.055	−6432.47	.077	.22	7.44	.061	−4673.14	.077
		(27.50)	(4.03)				(26.51)	(3.81)				(15.97)	(3.32)		
6	.31	21.83	.083	−11477.64	.096	.27	16.52	.085	−11126.56	.098	.30	10.73	.031	−7996.66	.043
		(37.13)	(5.85)				(33.88)	(5.74)				(27.76)	(3.10)		

[a] The logarithm of the maximized likelihood function, except for constant terms.
[b] t-statistics are in parentheses.
[c] Income elasticities measured at the mean value of income and consumption for each of the life cycle stages.
[d] Chow tests for a_i for regressions for relatively more and relatively less nutritious foods using linear and logarithmic forms indicated there were significant differences between the a_i's in every stage of the life cycle. For the justification of the Chow test for this type of problem see Toyoda. The Chow test is well behaved even under heteroscedasticity as long as at least one of two sample sizes is very large.
[e] At the maximized λ.

nutritious foods derived at the maximum value, $\hat{\lambda}$, for the general functional form. For all food, the highest income elasticity derived was for Stage 4 ($\hat{\lambda}$ = .45) and the lowest for Stage 0 ($\hat{\lambda}$ = .34). For foods that are relatively more nutritious components of diets, the income elasticity was highest for Stage 6 (no children present and the housewife was over 40 years of age ($\hat{\lambda}$ = .27) and lowest for Stage 1 ($\hat{\lambda}$ = .31). For foods that are relatively less nutritious components of diets, the income elasticity was highest for life cycle Stage 5 ($\hat{\lambda}$ = .22), when the average age of the children is over 17 years, and lowest for Stage 0 ($\hat{\lambda}$ = .16). As households move from "single persons" to "married with small children" (under six years) their food expenditure response to an increase in income increases for all foods, relatively more nutritious and less nutritious foods. This increased food expenditure response continues for relatively less nutritious foods throughout child-rearing ages and decreases for older person households when children are gone. However, for all foods and foods that are relatively more nutritious dietary components, the food expenditure response is more volatile. When children are between six and twelve years, there is a noticeable decline in the income elasticity. This response then rises and reaches a peak when children are in the teenage years, declines again when children are over seventeen and increases for older person households. Thus, the elasticities imply (*a*) households will spend a greater proportion of a greater income on all food when there are teenagers in the household; (*b*) older households without children will spend a greater proportion of a greater income on relatively more nutritious foods, and (*c*) households where the children are older and some, in fact, are young adults, will, on the average, spend the greatest proportion of a greater income for relatively less nutritious food. The further implications are that as the average age of the children in households increases, households will spend a greater proportion of a greater income on foods that are relatively less nutritious components of diets; and that as the proportion of older households without children increases, a greater proportion of greater household incomes will be spent on relatively more nutritious foods.

Summary and Conclusions

Income elasticities for all food, relatively more nutritious and less nutritious components of diets for all stages and seven designated life cycle stages, were estimated using the general functional form utilizing a Box-Cox transformation as proposed by confidence interval for λ varied no more than .08 from the value of $\hat{\lambda}$. The hypothesis that the linear or logarithmic functional forms which were also estimated fit the data was rejected at the 5% level.

Using the mean value in the estimating equations, the highest income elasticity using the flexible functional form was for Stage 4 (average age of children between 12 and 17 years) and the lowest for Stage 0 (single people) for all food. This is logical since food is a higher priority for households, generally, if they have teenage children and a lower priority for single people.

Interestingly, the income elasticity for the relatively more nutritious food components was highest for Stage 6. This implies that older people have a greater appreciation for nutrition. Nutrition education efforts to be most cost-effective should be directed to other household groups. For less nutritious food, the highest income elasticity was for Stage 5 (where the average age of the children was over 17 years). It may well be that relatively less nutritious foods are more appealing to teenagers and young adults. This has serious implications. Greater nutrition education efforts should be directed at those two groups who are just entering the labor force and for whom, over the lifetime, better health and higher productivity will have higher economic and noneconomic payoffs than for older persons.

Thus it would appear estimates of income elasticities based on linear and logarithmic functional forms may require reevaluation. Specific policy-relevant findings from this study indicate single-person households have lower income elasticities than households in any other life cycle stage for all food and for relatively less nutritious foods, while older people in childless households have the highest income elasticity for relatively more nutritious foods. This may not accord with the preferences of those who would prefer households with younger children and younger, more productive, adults to spend high proportions of higher income on more nutritious foods.

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The Impact of Changing Marketing Margins on Farm Prices

B. S. Fisher

An important issue in the debate about the cost of marketing services is the incidence of a change in the charges associated with marketing an agricultural product. Traditionally the treatment of this question has been divided into two parts, the first being consideration of the incidence of charges associated with the introduction of new services and the second, consideration of the incidence of a change in the cost of an existing service. This note will deal with the latter.

The incidence of a change in the cost of existing marketing services may be explored graphically by the methods outlined by Tomek and Robinson (pp. 120–4). Although it is possible to arrive at broad conclusions about the incidence of changes in the level of marketing costs, it is difficult to quantify these effects using graphical methods. However, by employing a diagram such as figure 1 (c), it is possible to derive a relationship which may be used to quantify the effects of an exogenous change in marketing charges on retail and farm prices. For ease of illustration it is assumed that the market operates on only two levels, that is, the farm level and the retail level.

In figure 1 demand at the retail level is denoted as Dx. Supply at the farm level is denoted as S. For present purposes it is assumed that the quantity of the good is measured in terms of retail weight. The demand for the marketing services needed to transform the good as it moves through the marketing chain can be derived as the vertical difference between supply at the farm level and demand at the retail level. The derived demand for marketing services is denoted as Dm. In the present paper it is assumed that the supply of marketing services, Sm, is perfectly elastic. Such a case would exist, for example, where there is excess capacity in the service industry. The interaction of the demand and supply of service functions establishes the price paid for services, that is, the marketing margin. The margin before the change in the cost of existing marketing services is the difference between Px_0 and Pa_0, that is, the difference between the retail price and the farm price.

With reference to figure 1 (c), it can be seen that a small change in the margin, δM, represented by the difference between Sm_1 and Sm_2, leads to a change in both the retail and the farm price and a change in the quantity sold, δQ. The present paper is concerned only with cases where the change in the marketing margin is a result of exogenous shifts in the supply of marketing services, such as that caused by an increase in real wages, for example. The change in the margin, δM, can be decomposed into its effect on the farm and retail prices. That is,

$$\delta M = r + f, \tag{1}$$

and the proportion of the increase borne by the farmer is given by

$$I_f = f/(r + f). \tag{2}$$

If it is assumed that the demand and supply curves are linear over the range, δQ, then the distances r and f are related to the slopes of the demand and supply curves, respectively. Although empirical estimates of the slopes of demand and supply response functions are often reported in the literature, these are of little use in a general analysis because slope estimates are dependent on the units of measurement chosen by the investigator. For general application it is necessary to have a formula based on elasticity estimates because these are readily available, widely understood, and independent of the units of measurement. Such a formula can be derived using figure 1 (c). From the diagram it can be seen that the direct price elasticity of demand at equilibrium is

$$\eta = \frac{\delta Q}{r}\,\frac{Px}{Q}, \tag{3}$$

and that the direct price elasticity of supply is given by

$$e_a = \frac{\delta Q}{f}\,\frac{Pa}{Q}. \tag{4}$$

Reexpressing equations (3) and (4) with r and f on the left-hand-side and substituting into equation (2) results in an expression for the farmers' share of an increase in marketing charges. This relationship can be written as

$$I_f = \frac{1}{1 + e_a/\alpha\eta}, \tag{5}$$

where $\alpha = Pa_0/Px_0$ and η takes its absolute value.

It is immediately obvious that farmers will pay 100% of any increase in marketing charges if the elasticity of supply is zero. In the case where

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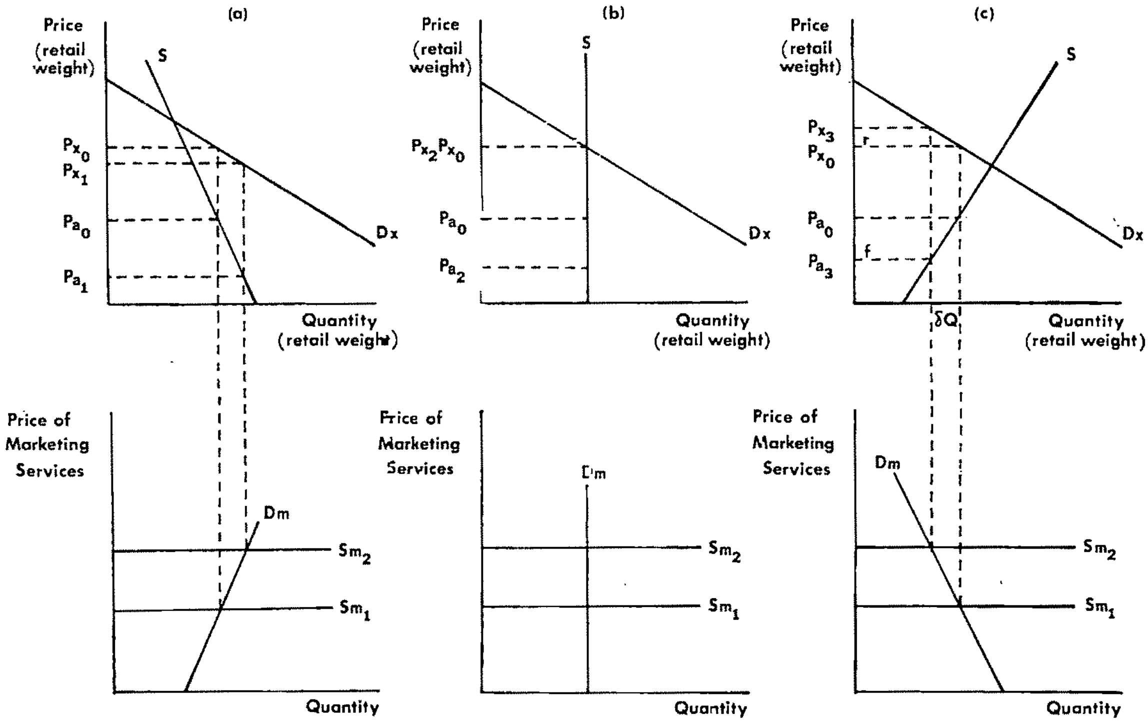

Figure 1. Producer and consumer shares of an increase in marketing charges given different elasticities of supply

$e_a = \alpha\eta$, the increase in charges is shared equally between producers and consumers.

The graphical approach and the resulting equation for the farmers' share of an increase in charges for existing marketing services depends implicitly on the assumption that the elasticity of substitution between agricultural products and other inputs into the marketing sector, σ is zero. This assumption can be relaxed if a mathematical model of a competitive marketing sector, such as the one outlined by Gardner (pp. 399–409), is used. The model employed by Gardner consists of six equations describing a food-processing sector which uses two factors of production, agricultural products and other marketing inputs. The market is described by a production function, a retail demand equation, two input supply equations and two equations setting out the marginal conditions for profit maximization. The effect on market equilibrium of a change in the cost of existing marketing services can be analyzed by differentiating the equations in the model with respect to the cost of marketing services. Using Gardner's nomenclature, this results in a three-equation system of the form:[1]

$$(6)\quad O = -\left[\frac{S_b}{\sigma} + \frac{1}{e_a}\right]E_{aT} + \frac{S_b}{\sigma}E_{bT} + E_{p_xT}$$

[1] See Gardner (p. 400 and appendix) for details of the derivation of this system.

$$(7)\quad e_T = \frac{S_a}{\sigma}E_{aT} - \left[\frac{S_a}{\sigma} + \frac{1}{e_b}\right]E_{bT} + E_{p_xT},$$

$$(8)\quad O = S_aE_{aT} + S_bE_{bT} - \eta E_{p_xT},$$

where a and b are the quantities of the agricultural product and the other marketing inputs, respectively; S_a and S_b are the relative shares of a and b, for example, $S_a = aP_a/xP_x$; e_b is the own price elasticity of supply of marketing inputs other than agricultural products; and E_{aT} E_{bT}, and E_{p_xT} are total elasticities which indicate how the first subscripted variable responds to a change in T. T. represents an exogenous factor which shifts the supply of marketing services upward, thus increasing the price of the services.

The farmers' share of an increase in marketing charges is given by the expression

$$(9)\quad I_f = \frac{|\delta p_a/\delta T|}{|\delta p_a/\delta T| + |\delta p_x/\delta T|}.$$

Solving the system of equations (6), (7), and (8) to obtain expressions for the partial derivatives in (9) and substituting into (9) results in the following expression for the farmers' share of an increase in marketing charges.

$$(10)\quad I_f = \frac{\left[\frac{\eta}{\sigma} + 1\right]\frac{\alpha}{e_a}}{\left[\frac{\eta}{\sigma} + 1\right]\frac{\alpha}{e_a} + \left[\frac{1}{\sigma} + \frac{1}{e_a}\right]},$$

where η takes its absolute value. Taking the limit of equation (10) as σ approaches zero gives equation (5), the result obtained from figure 1(c).

Equations (5) or (10) may be used to show how the burden of any exogenous change in marketing charges will be shared by producers and consumers, given estimates of the necessary parameters. For example, the equations may be used to analyze the effect on the price received by farmers of an increase in wage rates in the service sector or an increase in the price of fuel. Both the aforementioned charges will cause the supply curve for marketing services to shift upwards, thus increasing the marketing margin. As an illustration, equation (5) has been used to show the incidence of a change in the cost of marketing services given different elasticities of supply and demand. Tables 1 and 2 illustrate the shares under the assumptions that $\alpha = 0.52$ and $\alpha = 0.34$, respectively. The values for α were calculated for the Sydney beef market over two time periods. The average value for α in the market for the period 1971 to 1978, excluding the years 1975 and 1976 was 0.52. The years 1975 and 1976 were years in which the farm price of beef was depressed. The average value for α in those years was 0.34. In the case of both tables it is assumed that $\sigma = 0.0$. The estimated shares are sensitive to a change in the assumption that the elasticity of substitution is zero. For example, for the combination $\eta = 1.3$, $e_a = 0.3$, $\alpha = 0.52$, and $\sigma = 1.0$, the farmers' share of an increase in the cost of marketing services is 0.48 compared to 0.69 in table 1. It is likely, however, that the elasticity of substitution of marketing services for beef is close to zero.

The above formulas are applicable in cases where the demand and supply curves have the usual slopes. An interesting case arises when the slope of the supply function is negative, something that may occur in the short run in the beef industry (see, for example, the evidence presented by Tryfos or Freebairn). The effect on prices at retail and the farm gate of a change in marketing charges when the supply elasticity is negative is illustrated in figure 1 (a). In this case the demand curve for marketing services is positively sloped and it is possible, therefore, that in some cases the market will not reach equilibrium. In the example illustrated by figure 1, an increase in the size of the margin is consistent with a lower price at both the farm and retail levels. The difference between Px_0 and Px_1 on figure 1 (a) could be thought of as the amount by which the farmers' share of an increase in marketing charges exceeds 100%. The time paths of prices at both levels in the market may be traced with the aid of figure 1. The figure illustrates the changes that would occur as adjustment takes place over time. The figure shows that as a result of an increase in charges, prices at both the farm and the retail levels initially fall and then, as further adjustment takes place, prices rise.

The present note explores the effects on retail and farm prices of a shift in the supply curve for marketing services. Such a shift could be caused by changes in exogenous factors, such as wage rates or the price of energy, for example. The formulas that have been derived show that for most agricultural products, the major adjustment to a change in marketing charges will be made by farm prices. Farmers therefore have a strong economic interest in promoting efficiency in the service sector.

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Table 1. The Incidence of an Increase in the Cost of Existing Marketing Services When the Farm Price is High (Farmers' Share of the Increase)

Elasticity of Supply	Elasticity of Demand[a] 0.0	−0.50	−1.00	−1.30	−1.50
0.00	—	1.00	1.00	1.00	1.00
0.30	0.00	0.46	0.63	0.69	0.72
0.50	0.00	0.34	0.51	0.57	0.61
1.00	0.00	0.20	0.34	0.40	0.44

[a] The elasticity of substitution between agricultural and other inputs in the marketing process is assumed to be zero.

Table 2. The Incidence of an Increase in the Cost of Existing Marketing Services When the Farm Price Is Low (Farmers' Share of the Increase)

Elasticity of Supply	Elasticity of Demand[a] 0.0	−0.50	−1.00	−1.30	−1.50
0.00	—	1.00	1.00	1.00	1.00
0.30	0.00	0.36	0.53	0.60	0.63
0.50	0.00	0.25	0.41	0.47	0.51
1.00	0.00	0.15	0.25	0.31	0.34

[a] The elasticity of substitution between agricultural and other inputs in the marketing process is assumed to be zero.

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Crop Production Costs and Returns on Midwestern Organic Farms: 1977 and 1978

Georgia Shearer, Daniel H. Kohl, Diane Wanner, George Kuepper, Susan Sweeney, and William Lockeretz

Increasing costs of energy have had a serious impact on the cost and supply of fertilizers, particularly nitrogen fertilizers. The use of several pesticides has been banned or restricted, and restrictions are being considered for others. For these reasons, a reduction in the chemical and energy intensiveness of agriculture would be desirable, provided that agricultural production would not be reduced seriously or production costs appreciably increased. Organic farming represents a lower bound on chemical intensiveness and consequently is considerably less energy intensive as well. A study of such farms can provide information on the effect of reducing the use of farm chemicals on productivity and economic performance.

We have previously reported results of a three-year comparison of economic performance and energy intensiveness of crop production on fourteen pairs of midwestern mixed grain-livestock farms which do (conventional farms) and which do not (organic farms) use standard commercial fertilizers and pesticides (Klepper et al., Lockeretz et al. 1978). The value of crops produced on organic farms, per unit area of cropland, was about 11% lower than on conventional farms. Operating expenses were also lower on organic farms and net returns about the same. Energy use for each dollar's worth of crops produced on organic farms was only 40% of that used on the conventional farms. Two major limitations in the three-year comparison restrict the applicability of the results. First, the sample was small and selected in an ad hoc way, essentially by word of mouth, because no listing of organic farms was available when the study began. Second, the data were obtained during three years of relatively unfavorable conditions. On the basis of both agronomic principles and empirical measurements (Lockeretz et al. 1980), relative yields on organic farms compared to conventional farms can be expected to be better under adverse than under favorable growing conditions.

Because of these limitations, we extended our analysis of crop production on organic farms by analyzing a different sample for two additional years, 1977 and 1978. The results are reported in this paper.

Methods

In this section, we describe briefly this new sample, both the organic farms and the comparison farms. Then we discuss the cost and revenue calculations that form the basis of our analysis.

Selection of Farms

The organic farm sample for this study was drawn from a survey (Wernick and Lockeretz) which identified more than 250 farmers in the western Corn Belt who do not use standard commercial fertilizers or pesticides, who produce field crops (generally in association with livestock), and whose farms are over 40 hectares in size. For this study, we limited our sample to the crop enterprises of beef and hog-producing farms in Iowa, southern Minnesota, and northern Illinois that had been soil mapped. The twenty-three organic farms in the 1977 analysis represent all of the organic farms in our survey which met the above criteria and whose operators were willing to cooperate in the study. In 1978, the number of cooperating organic farms dropped to nineteen. Most of the sample farms were in Iowa (eighteen in 1977 and fifteen in 1978).

Whenever possible, the sample organic farms were compared to all beef and hog farms in each of the counties in which the organic farms were located. Depending on available data, some comparisons (notably, crop yields) were made with all farms, not just beef and hog-producing farms, in each of the counties.

The average farm size of the 1977 organic sample was 95.1 hectares, compared to 95.6 hectares for all beef and hog farms in the relevant counties (U.S.

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Department of Commerce). Here farm size refers to the amount of cropland, set-aside land, and permanent pasture. Farm buildings and woodland are not included. Although the average size of the two kinds of farms was nearly equal, the distribution of farm sizes was not. Organic farms under 40 hectares were excluded from the sample, whereas the group of beef and hog farms in the relevant counties included all sizes.

Land Capability

The quality of the land on the organic sample was compared to that on all farms in the relevant counties by determining the proportion of farmland in each capability class. For organic farms soil maps were used for this determination. For all farms in the same counties, the fraction of farmland in each capability class was taken from statistical sources (Illinois, Iowa, and Minnesota Conservation Needs Committees, and Soil Conservation Service).[1] The proportion of farmland in capability classes I and II (prime cropland) was 54% for the organic farms and 68% for all farms in the same counties. Capability classes I–IV (land suitable for cropping) accounted for 94% of the organic farmland and 96% of all the farmland in the same counties. Thus, the quality of the land on the organic sample and on all farms in the same counties was very similar. In both years, the percentage of land in classes I and II on organic farms was significantly and positively correlated with the comparable percentage for all farms in the relevant counties (1977: $r = 0.70$; 1978: $r = 0.62$, slope = 1.05). This shows that individual organic farms were roughly similar to all farms in the same counties in the fraction of land that is prime cropland. Most of the land suitable for cropping (94% of classes I–IV) was used for that purpose on organic farms.

Crop Mix

The crop mix on the organic sample was obtained from information supplied by the farmers. The only data on crop mix available for other farms were statewide data by type of farm for 1974 (U.S. Dep. of Commerce) and county-wide data for all types of farms for 1977 and 1978 (Illinois Cooperative Crop Reporting Service, Iowa Crop and Livestock Reporting Service, Minnesota Crop and Livestock Reporting Service). We estimated, for 1977 and 1978, the crop mix for all beef and hog farms in the relevant counties using the following assumptions: for a given crop and a given county, the fraction of land in that crop on a particular type of farm in 1977 or 1978 stood in a fixed ratio, independent of farm type, to the fraction of land in that crop in 1974 on all farms of that type in the state; the relative average farm size for the various types in a given county was the same as for the state as a whole; the proportional number of farms of each type in a county remained constant from 1974 to 1978.[2] Because of lack of data, we further assumed that oats are a constant fraction of the land in hay in each county, oats being raised primarily as a nurse crop for hay. The Census data on rotation and permanent pasture are unreliable, because farmers apparently do not distinguish consistently between the two, although the total pasture is correct. We therefore used the 1977 National Erosion Survey (Soil Conservation Service) to determine the proportion of land in permanent pasture in each state, and deducted the amount of rotation pasture from the Census data on total pasture. We further assumed that the ratio of rotation to permanent pasture for beef and hog farms in a given county was the same as for all farms in the state. From these assumptions, and the data sources, indicated, we estimated crop mix on all beef and hog producing farms in each county in 1977 and 1978.

Yields and Market Value of Production

Crop yields on organic farms were taken from farmer reports. A previous comparison of measured corn grain yields with yields as reported by farmers showed close agreement (Lockeretz et al. 1980). These yields were compared to yields on all farms in each respective county as reported in Agricultural Statistics (Illinois Cooperative Crop Reporting Service, Iowa Crop and Livestock Reporting Service, and Minnesota Crop and Livestock Reporting Service). Hay yields on organic farms in Minnesota and Illinois were the same as on all farms in the corresponding counties. On this basis, hay yields on organic farms and on all farms in the relevant counties in Iowa, which does not report hay yields, were assumed to be equal.

In all cases, the market value of production was calculated using season average prices reported by USDA Statistical Reporting Service. Organic farms were not credited with any premium price for their products. A previous survey (Wernick and Lockeretz) showed that premium prices are not a significant factor on this type of organic farm.

Expenses

Only operating costs were considered. Fixed costs were assumed to be the same on both kinds of

[1] For all farms in the relevant counties, the fraction of farmland in each capability class was taken from the 1967 Conservation Needs Inventory (Illinois, Iowa, and Minnesota Conservation Needs Committees). The 1977 National Erosion Survey (subject to revision) (Soil Conservation Service) showed little change in the area of farmland or the distribution of this land within capability classes between 1967 and 1977.

[2] For example, suppose that in the state as a whole in 1974, 50% and 25% of the land on cash grain and beef and hog farms, respectively, was in corn. Suppose also that the proportion of cropland in corn in a particular county in 1977 was 1.2 times that of the state in 1974. Then according to our assumption, 60% (1.2 × 50%) and 30% (1.2 × 25%) of the land on cash grain farms and beef/hog farms, respectively, in that particular county would be assigned to corn.

farms. This assumption seems justified in light of our previous finding (Lockeretz et al. 1975) that organic and conventional farms are virtually identical in machinery, equipment, and land quality. Methods of estimating operating costs on organic farms have been described previously (Lockeretz et al. 1975). The number of individual operations involved in crop production and the rate of application of materials, such as fertilizers, pesticides, and soil amendments, on county farms were taken from the Firm Enterprise Data System (USDA ERS) except that these farms were credited with the full fertilizer value of all manure produced.[3] Costs of inputs (with the exception of organic fertilizers, the cost of which was taken from farmer reports) were based on data given by USDA Statistical Reporting Service.

Energy Use for Crop Production

The methods we used to estimate energy use for crop production have been described previously (Lockeretz et al. 1975, Lockeretz et al. 1976). Estimates were based on fuel consumption for field operations and energy consumption for the production of materials used. Energy consumption for production of machinery and equipment and for transport of crops to market was not included.

Results

This section presents the major results of our analysis. Where possible, we present direct comparisons between the organic farms and the others.

Crop Yields

Table 1 shows average yields in metric tons per hectare (MT./ha.) of the predominant grains grown on the organic and county farms in 1977 and 1978. In 1977 the average organic corn yield was 8% lower than the average county-wide corn yield, soybean yields were nearly the same for the two groups, and oat yields were about 10% higher on organic farms. The low average corn yields on both kinds of farms in 1977 reflect serious drought in several of the counties.

1978 presents a different picture. It was an unusually favorable growing year throughout the western Corn Belt. Organic corn yields were about 18% lower than those on all farms in the relevant counties, a difference that was significant at the 99% confidence level. Organic soybean yields were about 7% lower, and oat yields were 6% higher on organic farms. The differences in soybean and oat yields were not significant.

Table 1 also shows that organic and county yields for a given crop were significantly correlated with each other. This indicates that the organic farms were similar to all farms in the corresponding counties with regard to enviornmental factors that affect yields.

Fraction of Total Farmland in Various Uses

Table 2 shows land in crops, permanent pasture, and the set-aside program. (Land use for other purposes, such as buildings and woods, is not included.) Less land is used for corn on organic farms than on all-beef and hog-producing farms in the corresponding counties. More land is used for oats, a nurse crop for hay, on organic farms. The total fraction of land in hay and pasture is about the same on the two kinds of farms. However, less of this land is in permanent pasture and more in rotation hay and pasture on the organic farms. Although there may be differences in erosion resulting from the difference in crop mix, we do not assign a dollar value to this.

Costs and Returns for Crop Production

Table 3 gives economic data for each of the major crops and for all crops. The first column of table 3

[3] The fertilizer value of manure was computed from the density and type of livestock, taking into account its nutrient content (Ensminger), handling losses, and the effectiveness of manure nutrients compared to commercial fertilizers (Ensminger, Peele et al., and Tisdale and Nelson). Livestock density and type were estimated by methods analogous to those used for crop mix.

Table 1. Average Grain Yields on Organic Farms and on all Farms in Corresponding Counties

Year	Crop	No. of Organic Farms	(1) Yield Organic Farms (MT./Ha.)	(2) Yield All farms (MT./Ha.)	% Difference [(1 − 2) ÷ average]100	Correlation between Organic and County Yields (R)
1977	Corn	21	4.90	5.31	−8.0	0.749
	Soybeans	19	2.23	2.26	−0.1	0.508
	Oats	21	2.37	2.14	+10.2[a]	0.604
1978	Corn	19	6.20	7.42	+17.9[b]	0.402
	Soybeans	16	2.38	2.56	−7.3	0.715
	Oats	17	2.43	2.29	+5.9	0.500

[a,b] Differences between organic and all farms statistically significant at the 95% and 99% levels, respectively (based on 2-sided t-tests for paired samples).

Table 2. Average Percentage of Land in Various Uses on Organic Farms and All-Beef and Hog-Producing Farms in Corresponding Counties

	1977		1978	
	Organic Farms	All Farms	Organic Farms	All Farms
Cropland	(%)			
Corn for grain	28.9	38.1[b]	26.7	38.5[c]
Corn for silage	4.7	5.0	2.6	4.9
Soybeans	18.6	16.6	18.1	17.2
Wheat	1.9	0.3	0	0.1
Oats	16.8	7.5[c]	14.7	7.4[c]
Hay and rotation pasture	22.4	14.9[b]	21.6	13.9[b]
Other	0	0.5	2.6	0
Permanent pasture	6.8	17.1[c]	9.0	15.3[a]
Set-Aside program	—	—	4.7	2.8[b]
	(hectares)			
Total farmland area	95.1	95.6	91.3	97.8

[a,b,c] Differences between organic and all farms statistically significant at the 90%, 95%, and 99% levels, respectively (based on 2-sided t-tests for paired samples).

shows the value of production per hectare of cropland. In the poor growing year, 1977, the only crop that showed a significant difference in value of production between the two kinds of farms was oats. However, oats are grown mainly as a nurse crop for hay. Soybeans yielded the highest value of production on both kinds of farms. The value of hay and rotation pasture was somewhat higher than that of corn in 1977. The high value of hay and rotation pasture compared to corn arises from the high current price of hay compared to corn, and low corn yields in 1977. Expenses were highest for corn, with the result that in 1977, the highest net returns were from soybeans, followed by hay and rotation pasture, with corn coming in a poor third. In 1977 there were no significant differences between organic and conventional net returns for any of the crops except oats, for which net returns on organic farms were higher.

Under the more favorable growing conditions of 1978, corn—the crop which is apparently most vulnerable to adverse conditions—became more profitable. In 1978, the most profitable crop again was soybeans, with corn about equally as profitable as hay and rotation pasture. The value of production of corn was significantly higher on all farms in each county than on organic farms. However, because of differences in expenditures, there were no

Table 3. Average Costs and Returns from Crop Production on Organic Farms and All-Beef and Hog-Producing Farms in the Same Counties ($/ha. of cropland)

Year / Crop	No. of Organic Farms	Value of Production		Operating Expenses		Net Returns	
		Organic Farms	All Farms	Organic Farms	All Farms	Organic Farms	All Farms
1977							
Corn	21	380	417	126	178[c]	254	240
Soybeans	19	482	477	84	101	398	376
Oats	21	235	161[a]	64	44[a]	170	116[a]
Hay and rotation pasture	23	422	412	96	64[c]	326	348
All Crops	23	384	407	95	129[c]	289	278
1978							
Corn	19	484	571[c]	143	195[c]	341	375
Soybeans	16	568	610	94	96	474	514
Oats	17	217	178	69	44[b]	148	133
Hay and rotation pasture	19	457	435	99	72[b]	358	363
All Crops	19	440	527[c]	107	143[c]	333	384[a]

[a,b,c] Differences between organic and all farms statistically significant at the 90%, 95%, and 99% levels, respectively (based on 2-sided t-tests for paired samples).

significant differences between the two kinds of farms in net returns for any of the individual crops in 1978.

Expenses on organic farms were lower for corn and soybeans and higher for oats and hay than on all farms in each county. The lower expenses for corn production on organic farms reflect the nonuse of standard fertilizers and pesticides. The higher expenses for the production of oats, hay, and rotation pasture on organic farms reflect a practice common among organic farmers—the application of commercial organic soil amendments of negligible nitrogen, phosphorus, and potassium (N, P, K) content to hay and oats. In contrast, conventional farms add few, if any, amendments to hay or oats.

Table 3 also shows whole-farm costs and return for crop production, calculated by combining the data on individual crops and on the proportional area in each crop (from table 2). In 1977, the year in which growing conditions were poor, the average value of crops produced on organic farms was only slightly lower than on all farms of the same type. Expenses were also lower, and net returns for the two groups were similar. In contrast, in 1978, a year in which growing conditions were well above average, the value of production on organic farms was considerably lower than on all-beef and hog farms in the same counties. The difference between the two groups in expenses was almost the same in the two years. But in 1978, unlike 1977, the difference in value of production was too large to be offset by the difference in expenses; net returns were lower (13%) on organic farms.

Energy Consumption

Energy use per dollar of crops produced is shown in table 4. The most energy-intensive crop on both kinds of farms was corn, which also shows the largest difference between the two groups in energy use. The overall lower energy use on organic farms is because of their lower energy use for corn together with the smaller proportion of cropland in corn. Energy use per dollar of crops produced on all-beef and hog farms was lower in 1978 than in 1977 because of higher production in 1978, rather than lower energy inputs per unit area.

Conclusions

The results support our earlier conclusion (Klepper et al., Lockeretz et al. 1978) that under unfavorable growing conditions, crop production on organic farms is as profitable as on conventional farms. In contrast, under favorable growing conditions, conventional farms outperform organic farms.

Despite major differences in agricultural practice between the two kinds of farms, differences in net returns were modest, even under conditions which were extremely favorable for conventional practice. This gap may narrow if costs of chemical inputs rise, although simultaneous changes in other costs and in crop prices may obscure this effect.

The results of this study show that an alternative agricultural system characterized by a different crop mix and markedly less chemical input, produced crop yields and net farm income which were close to those achieved on conventionally managed, commercial-sized, midwestern Corn Belt, mixed crop/livestock enterprises. We believe that an examination of productivity under management intermediate between the extremes studied here would be fruitful. It is important to explore the possibility of successful agriculture with fewer

Table 4. Average Energy Use for Crop Production on Organic and All-Beef and Hog-Producing Farms in the Same Counties

Year / Crop	No. of Organic Farms	Energy Use (1) Organic Farms (Mcal. consumed/$ produced)	Energy Use (2) All Farms (Mcal. consumed/$ produced)	The Ratio of Energy Used per Dollar Produced 1:2
1977				
Corn	21	2.9	9.2[b]	0.31
Soybeans	19	1.4	1.5	0.90
Oats	21	1.6	1.5	1.08
Hay and rotation pasture	23	1.8	1.4[b]	1.29
All Crops	23	1.9	5.1[b]	0.39
1978				
Corn	19	2.6	6.1[b]	0.42
Soybeans	16	1.3	1.2	1.06
Oats	17	.7	1.5	1.13
Hay and rotation pasture	19	1.3	1.6[a]	0.81
All crops	19	1.8	4.1[b]	0.44

[a,b] Differences between organic and all farms statistically significant at the 95% and 99% confidence levels, respectively (based on 2-sided t-tests for paired samples).

energy intensive inputs in an era of higher costs and uncertain availability of the traditional inputs.

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Impacts On Farmers of a Computerized Management Decision-Making Model

David L. Debertin, Charles L. Moore, Sr., Larry D. Jones, and Angelos Pagoulatos

A number of states are currently developing comprehensive programs for making computerized decision aids available to farmers (Harsh; Infanger, Robbins, Debertin; LaDue; Schoonaert; Walker). While Cernea and Tepping have outlined procedures for a general evaluation of agricultural extension projects, only a few efforts have been conducted with a corresponding research effort aimed at quantifying the impacts of computerized decision models on farmer behavior. (Erickson; Erickson, Sandborg, Byers; Knoblauch). This paper summarizes results from a pilot research project designed to provide measurements of changes in farmer behavior as the result of being exposed to a computerized planning model in extension.

This study is an attempt to determine the specific management decisions that the farmers intended to make as a result of having been exposed to the planning model. A follow-up effort one year later identified managerial decisions that actually had been implemented as a result of exposure to the planning model a year earlier. Hence, both farmers' intentions and realizations were measured in this study.

The Experimental Design

Twenty-six commercial corn and soybean farmers were invited to participate in a workshop at the University of Kentucky using the KASH PROFITS computerized planning model. The KASH PROFITS model is a linear programming model designed to assist corn and soybean farmers in making planting, tillage, harvesting and other management decisions. It is a modified version of model B-90 originally developed over several years at Purdue, and is perhaps the most widely used comprehensive computerized management model in extension education. Details of the model construction can be found in a number of research and extension publications (Brink, McCarl, Doster; Debertin et al.). Because of its widespread use, the model has been subject to a more thorough testing under actual farmers' conditions than have most other computerized decision aids, and the behavior of the model is normally quite reliable (McCarl et al.).

The farmers participating in the three-day workshop were not a random sample, but were representative of progressive commercial grain farmers in Kentucky. Nearly all were members of Kentucky's farm business analysis program, a record and analysis system sponsored by the Department of Agricultural Economics. Acreages, ages, educational levels did vary widely (table 1).

At the conclusion of the workshop, each farmer was asked to complete a questionnaire which requested detailed information with regard to the specific changes the farmer intended to make as a result of having used the model over the three-day workshop session. One year later, a follow-up questionnaire was mailed to each farmer who had participated in the workshop. This questionnaire requested detailed information with regard to the specific changes that were implemented as a result of their workshop experience one year later.

One year may not be a sufficient length of time to measure the total benefits gained from an educational experience. For example, farmers may not have sufficient time to make major decisions involving factors such as those involved in the purchase of additional land or the acquisition of major items of machinery. However, a survey of farmers one year after a workshop with respect to the changes they implemented should provide a better estimate of the effectiveness of an educational experience than if survey data were gathered only at the workshop conclusion.

Experimental Results

For the initial questionnaire, the following survey responses were possible:

(1) I intend to make the change.
(2) I am undecided.
(3) I do not intend to make the change.
(4) If "no" or "undecided," it is because:
(a) I could not figure out my output.
(b) KASH PROFITS said a change was not profitable.
(c) KASH PROFITS does not represent my farm.
(d) I gave the computer the wrong information.

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Table 1. Characteristics of Farmers Attending Workshop, 1976

	Mean	Range
Average age (years)	34.12	22–53
Years farming	11.62	1–31
Educational level (years)	15.17	11–19
Acres corn grown during 1976	534	39–1,754
Acres soybeans grown during 1976	280	0–870
Months of labor used on the farm (owned and hired)	43.6	6.6–159.1
Investment in machinery	$101,724	$13,699–$316,019
Farm and family earnings[a]	$128,007	$17,004–$381,031

Source: Debertin, Moore, and Jones.
[a] Defined as return to capital, operator's labor and management.

(e) Not enough time to make the change this year.

(f) I cannot make the change because of circumstances outside of my control.

On the follow-up questionnaire, the following survey responses were possible:

(1) No, I did not make the change.

(2) Yes, I did make the change as suggested by the model.

(3) I made a partial change.

(4) This question does not apply to my farming situation.

Table 2 summarizes the twenty-five questions contained on the initial and follow-up questionnaire.

Table 2. Survey Questions

As a result of the KASH PROFITS workshop, will (did) you:

a. change the acres of corn you grew?
b. change the acres of single crop soybeans you grew?
c. change the acres of wheat-double crop soybeans you grew?
d. change the acres of corn silage you grew?
e. change the acres of land you rented in?
f. change the acres of land you rented out?
g. change the amount of farm-held storage?
h. change the date you began planting corn?
i. change the date you began planting soybeans?
j. change the hours of labor you used during planting?
k. change the size and number of tractors for planting?
l. change the date when you began harvesting corn?
m. change the date when you began harvesting single crop soybeans?
n. change the hours of labor for planting?
o. change the hours of labor for harvest?
p. change the size or number of combines you used?
q. change the timing of land preparation?
r. change the timing of post-plant tillage?
s. hire in a custom combine for corn?
t. hire in a custom combine for soybeans?
u. hire in a custom combine for wheat?
v. hire in custom silage harvest?
w. hire out your combine?
x. purchase a farm dryer, or change the time of dryer used? used?
y. change the amount of crop you stored on the farm?

Table 3 summarizes results from the initial questionnaire that farmers completed at the conclusion of the workshop. At the end of the workshop, a substantial number of farmers indicated a desire to make some changes in their farming operations as a result of having used the model. Some thirteen farmers indicated they would adjust their corn acreages, and fourteen said they would change their soybean acreages as a result of having worked with the model (questions *a* and *b*). However, this was not true for some other decisions. None were willing to change the acres of land rented out (question *f*). Only one farmer indicated a willingness to change corn silage acreages (question *d*), the size or number of tractors (question *k*), or hire a custom combine for wheat (question *u*). Ten farmers indicated a willingness to change soybean planting dates (question *i*) while nine were willing to change planting dates for corn (question *h*). Nine farmers also indicated a willingness to change the hours of labor used during harvest (question *o*) and change the amount of farm stored crop (question *g*).

The most common reason for an unwillingness to make a change was that the model indicated the change was not profitable. For example, farmers at the workshop experimented with the option of adding a tractor or a new combine. In many instances, these experiments indicated that new machinery would not increase net returns.

Factors outside the control of the farmer was another common reason for not making a change. These factors include long-term lease-rental commitments, credit restrictions, and the unavailability of land to rent in or labor to hire. A few farmers indicated that they did not have time to make the change for the upcoming cropping season but would the following year. Output from the model is quite lengthy and complicated. However, there was little evidence that farmers participating in the workshop had difficulty interpreting their output, or that they supplied incorrect information to the model.

An analysis was conducted to determine the extent to which linkages existed in farmer responses to the questions on the evaluation forms. This was an effort to determine if a farmer who had been exposed to a computerized decision model tended

Table 3. Frequency of Response to Questionnaire at Conclusion of the Workshop

Response	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	Sum	Mean
Left blank	4	1	2	3	1	2	1	1	1	2	2	1	1	1	2	3	2	2	3	2	2	1	2	3	3	47	1.88
Could not figure out output	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	1	1	0	0	0	1	0	7	0.28
Change not profitable	3	4	5	3	3	14	9	12	13	14	23	15	14	15	11	18	15	14	16	14	19	11	8	10	9	290	11.6
Does not represent farm	1	1	1	6	1	4	0	1	0	0	0	2	1	0	1	0	0	1	2	2	2	4	3	2	2	37	1.48
Supplied wrong information	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0.12
Not enough time this year	1	0	7	0	6	0	2	0	0	1	[illegible]	0	0	1	0	0	1	0	0	0	0	0	2	0	0	22	0.88
Factors outside control	3	5	6	7	10	4	8	3	2	1	[illegible]	2	4	5	2	0	1	1	1	2	1	3	3	4	2	81	3.24
Will make change	13	14	5	1	5	0	5	[illegible]	10	8	[illegible]	5	5	2	9	2	6	6	3	5	1	2	5	6	9	137	5.48
Other written in responses	0	0	0	6	0	2	0	0	0	0	0	1	1	2	1	2	1	1	0	0	1	5	2	0	1	26	1.04

to make changes on certain kinds of decisions, but not to make changes on other decisions. For example, a farmer might be willing to change the timing of both planting and tillage and harvesting operations but be reluctant to make decisions dealing with capital investment such as for machinery or crop storage.

From the frequency counts contained in table 3, a correlation matrix was developed. The simple correlation coefficient between each pair of evaluation questions provided a measure of the extent to which each pair of questions was linked. Factor analysis is also useful in identifying major sources of variation in a data set, and was used here to supplement and verify the correlation analysis results. Four factors were found to summarize over 90% of the variation in the data set, and factor scores using a varimax rotation grouped the questionnaire responses into four distinct categories: (*a*) those dealing with corn and soybean acreages and crop storage decisions (factor 2), (*b*) those dealing with double-cropping and storage-building decisions (factor 3), (*c*) those dealing with corn silage planting decisions (factor 4), and (*d*) all other decisions (factor 1). Farmers tended to behave similarly within each category of decisions.

Table 4 summarizes results obtained from the initial questionnaire in relation to the follow-up questionnaire. Hence, the extent to which farmers' intentions become realizations is assessed.

Nearly all of the farmers who indicated that they would not make a change did not make a change. Of those that indicated they would make a change, most did not make the entire change suggested, but rather made a partial change. This was particularly true with respect to corn and soybean acreages. A relatively large number who indicated a willingness to make a change did not follow through. This was particularly true for decisions dealing with labor and timing of planting, tillage, and harvesting operations (questions *h, i, j, l, m, o, q, r, s, t, w,* and *x*). However, a number of farmers who indicated that they would not make a change with respect to these decisions on the initial survey subsequently made a partial change.

Correlation and factor analysis were again used to identify four categories of decisions: (*a*) those dealing with labor availability and timing of planting and harvest decisions (factor 1), (*b*) those dealing with corn and soybean acreage decisions (factor 2), (*c*) those dealing with corn silage (factor 3), and (*d*) all other decisions (factor 4). Each of these categories was linked in that farmers' decisions with respect to changes were similar within each category.

Table 4. Frequency of Response to Initial and Follow-up Questionnaire, One Year after Workshop

Response to change suggested by model (initial and after one year)	Question																										
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	Sum	Mean
none or incomplete	5	5	5	5	5	5	5	5	5	5	5	6	[illegible]	5	5	5	5	5	5	5	5	6	5	5	5	127	5.08
no and did not	3	3	9	8	11	16	7	11	9	7	10	9	[illegible]	13	8	14	8	14	16	12	16	9	12	12	6	257	10.28
no and partial	0	0	1	0	0	0	7	1	0	[illegible]	8	4	[illegible]	2	4	1	6	1	0	2	1	0	1	3	1	48	1.92
no and did	1	1	2	0	1	0	0	0	2	[illegible]	1	1	0	0	1	0	1	0	1	1	0	0	2	1	3	20	0.80
no and does not apply	0	1	3	12	1	5	1	0	1	[illegible]	0	0	0	4	0	1	0	1	0	0	3	9	1	0	1	45	1.80
undecided and did not	3	2	2	0	3	0	1	1	1	[illegible]	0	1	1	1	0	1	0	0	1	1	0	0	0	1	3	23	0.92
undecided and partial	4	3	0	0	0	0	1	0	0	[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	0.36
undecided and yes	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0.12
undecided and does not apply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
yes and did not	1	2	1	0	2	0	1	2	3	[illegible]	1	2	3	1	4	0	3	2	2	3	0	0	2	3	4	46	1.84
yes and partial	8	8	3	0	1	0	3	1	2	1	0	2	1	0	2	1	3	2	0	1	0	1	2	0	2	44	1.76
yes and did	1	1	0	1	2	0	0	5	3	3	0	1	1	0	1	1	0	1	0	0	0	0	1	1	1	24	0.96
yes and does not apply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	4	0.16

The follow-up questionnaire requested that each farmer estimate by how much the workshop experience increased farm profits. Table 5 summarizes the results. Findings were somewhat bimodal. Seven farmers indicated that they did not know how to estimate the increase in profits attributable to the workshop. Eight farmers felt that the workshop experience did not increase farm profits. Those who indicated a dollar figure placed their estimates at \$100 to \$16,000. Nine of the participants who provided estimates indicated that profits were increased the following year by less than the total direct costs of the workshop to them of \$252. However, four farmers estimated profits to be increased by \$10,000 or more.

Conclusions

Farmer decision making is impacted by exposure to a large-scale, computerized, planning model. However, the extent to which decisions are impacted by the model depends greatly on the nature of the specific decision being considered and the farmer's particular operation. Farmers were willing to make changes in decisions relating to crop acreages upon exposure to model information. They were much less willing to make changes relating to machinery purchases, labor utilization, and land rental. These decisions are often more difficult to implement than decisions dealing with changes in crop acreages. Moreover, farmers may not maximize profits, but rather satisfy a subjective desire for a new piece of machinery. The model usually found acreages to be suboptimally allocated. For other decisions the model often indicated that a change was not necessary. Hence, farmers were properly following the advice of the model by not making a change.

A second conclusion is that farmers' intentions often do not develop into realizations. In many instances, intended changes were not realized by the end of the production period. Even though farmers planned to make a specific change in their operation as a result of the workshop, these changes were often only partially implemented, or not implemented at all. In a few cases, farmers planned a no-change decision but then implemented a change during the cropping season.

The scope of the evaluation was somewhat narrow. In evaluating the results of the workshop, direct changes in certain decisions were observed, such as changes in acreages and the size of machinery. However, one of the major impacts on farmers may not be these direct changes that were observed, but rather the total impact of the model on making the farmer better aware of the strengths and problems associated with the business. This greater awareness of the business could lead to long-term adjustments not evaluated. Another benefit not evaluated is the fact that farmers were able

Table 5. Farmers Estimates of the Increase in Farm Profits for the KASH PROFITS Workshop, Follow-Up Questionnaire

Farmers Estimates of Value	No. of Farmers	Ratio of Increase in Farm Profits/Cost of Workshop
No way to determine or did not respond to question	7	—
Did not increase farm profits	8	0
Increased farm profits by (\$):		
100	1	.3967
500	2	1.984
2,000	1	7.936
3,000	1	11.905
5,000	1	19.841
6,000	1	23.810
10,000	3	39.683
16,000	1	63.492
Estimates of cost per farm:		
Registration fee (includes cost of:	\$100	
Computer time	(40)	
Keypunch operator salary	(20)	
Clerical assistant salary for checking input forms	(15)	
Banquet cost)	(25)	
Professional faculty time per farmer (6 hours @ \$12 per hour)	\$72	
Food and lodging costs	\$80	
Total costs per farmer	\$252	

to get away from their business for a few days to study the interaction of its parts. A number of farmers commented on this. This conclusion is in agreement with Stone and Erickson's arguments that providing a basic understanding of interactions within a business is one of the more important benefits of working with computerized decision models.

Finally, the perceived value of the workshop varied greatly among farmers. The evaluation one year after the workshop found farmers rather divided into two groups—those who felt the workshop was worth very little and those who felt the workshop was worth a great deal of money Further research is needed to verify findings in this analysis with respect to the extent to which computer models impact farmer decision making. A length of time between surveys greater than a year may be necessary to determine if farmers will make changes with respect to decisions such as land purchases.

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The Inverse Relationship between Productivity and Farm Size: A Test Using Regional Data from India

Anil B. Deolalikar

The farm size-productivity debate for India needs little introduction; it has occupied a prominent position in the agricultural economics literature since 1962, when Sen observed that Indian farm management data revealed an inverse relationship between farm size and yields per acre. Since then, no fewer than twenty journal papers have appeared on this subject (Sen 1975).

The objective of this paper is to test two hypotheses that were either not given enough attention or left unresolved in the debate. The first is that the inverse relationship is valid for all of Indian agriculture; it is not merely a phenomenon observed in a few sample villages. This means a test of the hypothesis that the small farm sector as a whole is more productive than the large farm sector in Indian agriculture. The second hypothesis is that the inverse relationship is true only of a traditional agriculture, and that it breaks down with technical progress.

A methodology is developed below which uses cross-sectional regional data to test the two hypotheses simultaneously. On applying this methodology to Indian district-level data (272 districts) for 1970–71, it is found that the hypothesis of the small farm sector being more productive than the large farm sector cannot be rejected at low levels of agricultural technology, but can be rejected at higher levels. This suggests that the inverse relationship between yields and farm size, although valid for a traditional agriculture, cannot be assumed to exist in an agriculture experiencing technical change.

Previous Studies

A shortcoming of previous investigations into the inverse relationship was that they were based on microdata, collected in most cases by the Indian Farm Management Studies (FMS). Consequently, not much could be said about the relationship outside these sample districts. Indeed, data from non-FMS districts did not always bear out the inverse relationship. Using farm-level data from villages in Punjab, Haryana, and Uttar Pradesh, both Rudra and Rao (1967) could not detect any inverse relationship between farm size and yields. Saini, too, failed to find evidence of an inverse relationship in seven out of a total of twenty-five of his sample villages.

The inverse relationship thus has been far from an established fact: there always has been some controversy regarding its validity for all of Indian agriculture. None of the previous studies were able to answer satisfactorily the question: Is the small farm sector as a whole more productive (in the sense of having greater yields per acre) than the large farm sector? One reason for this inability was the use of a model which could use only microlevel data for the testing of the hypothesis. Typically, the model used by researchers was

$$Y_i = a + bX_i + e_i, \quad (1)$$

where Y_i is output or output per acre on farm i or group of farms i, X_i is size (in acres) of the farm or group of farms, and e_i is error term having zero mean, uniform variance, and no correlation with X_i. An estimated b coefficient less than unity (if Y is output) or negative (if Y is output per acre) then confirmed the inverse relationship.

Because X in equation (1) is expressed in absolute terms, the sample used in testing the hypothesis cannot extend beyond a fairly homogenous group of farms. For, obviously, a farm size of 10 acres does not mean the same thing in an arid region like Rajasthan as it does in an irrigated area like West Bengal. In the latter, it can be classified as a large farm size, but, in the former, it is clearly small. Farm size is thus a relative concept, and its measurement in absolute terms can be quite misleading, especially in a large and heterogenous sample.

Another issue that has not received much attention in the literature is that of technical progress in agriculture. A majority of the studies on the inverse relationship used data collected in the 1950s—almost a decade before the advent of the Green Revolution. This obviated the need for discussing the differential impact of technical progress on the productivities of small and large farms. The few studies that did use post-Green Revolution data arrived at ambiguous results. Bhattacharya and

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Saini found, for instance, that the inverse relationship had changed after the Green Revolution in one district of the Punjab but had remained unchanged in another district. Using sample data for 1969–70 from West Godavari district, Rao (1975) found a positive relationship between output per acre and farm size. Bardhan confirmed the inverse relationship for Thanjavur district of Tamil Nadu but rejected it for Ferozepur district of Punjab. There is some theoretical basis for expecting the inverse relationship to be weakened, or even replaced by a positive relationship between yields and farm size, with technical change, but relatively few studies have systematically developed and tested this argument. This is discussed more fully in the next section.

Some Hypotheses

A priori there are several reasons for expecting small farms to have greater yields than large farms. For the sake of brevity, we discuss only the reason most commonly accepted by researchers in the field. First offered by Sen, the argument runs as follows: an imperfect labor market in a dual agricultural economy produces different shadow prices for labor to the small subsistence farmer, who uses his own labor on the farm, and the large commercial farmer, who relies mainly on hired labor. The imputed price of labor to the former is lower than that to the latter, resulting in a more intensive application of labor and complementary inputs on the small farm. This naturally raises the yields per acre on the small farm relative to those on the large farm.

Although the neat division between peasant and capitalist farming assumed by the above argument is somewhat exaggerated, there is some basis for the argument. Data have consistently shown that small farmers use more labor per acre than large farms (Bharadwaj). This must mean a lower valuation of own labor by the small farmer.

With technical progress, however, family labor becomes less important in determining land productivity,[1] while other current inputs like fertilizer become much more important.[2] Since the latter are factors whose use depends largely on cash and credit flows, large farmers—who have greater access to both—end up using more of these inputs than small farmers. The earlier adoption of the new technology by large farmers is a well-documented fact (Frankel, Griffin, Rao 1975)—one that reduces or even reverses the yield-advantage of small farmers.

[1] The share of labor in total output has been observed to decline with technical change, both by studies using cost-accounting data (Rao 1975) and by those fitting production functions (Chinn).

[2] Using a Taiwan sample, Chinn has estimated production elasticities of 0.185 and 0.226 for fertilizer for the periods 1960–62 (pre-Green Revolution) and 1970–72 (post-Green Revolution), respectively.

There is evidence to suggest that the Green Revolution has removed the yield superiority of small farms. Using 1958–60 data from West Godavari district, Rao (1975) found inverse relationships between output per acre, labor use per acre, and fertilizer use per acre on the one hand and farm size on the other hand. Using a 1969–70 sample from the same district, however, he obtained an inverse relationship only between labor use per acre and farm size. Output per acre and fertilizer use per acre were both positively related to farm size. This seems to suggest that large farms enjoy higher productivity than small farms in the post-Green Revolution period primarily because of their more intensive use of fertilizer and other modern inputs.

The Model

We start with the definition of average productivity in a district as the weighted sum of productivities of each size class of farms in the district, with the weights being the share of total land area cultivated by a size class. Since the land shares of all the size classes sum to unity, average district productivity can be written as

$$(2)\qquad Y \equiv s_1Y_1 + s_2Y_2 + \ldots + s_{n-1}Y_{n-1} + \left(1 - \sum_{j}^{n-1} s_j\right)Y_n,$$

where Y is average district productivity, s_j is share of total area operated by the jth size class of farms, and Y_j is productivity of the jth size class. Expanding the parenthetical term and rearranging all the terms, gives us

$$(3)\qquad Y \equiv s_1(Y_1 - Y_n) + s_2(Y_2 - Y_n) + \ldots + s_{n-1}(Y_{n-1} - Y_n) + Y_n.$$

Now, if district-level data on average productivity (Y) and on the distribution of land across various size classes of farms (s_j's) are available, equation (3) can be estimated.[3] The estimating equation would be of the form,

$$(4)\qquad Y_i = Y_n + (Y_1 - Y_n)s_{1i} + (Y_2 - Y_n)s_{2i} + \ldots + (Y_{n-1} - Y_n)s_{n-1\cdot i} + v_i,$$

where i stands for the district and v is a disturbance term which has zero mean, uniform variance, and which is uncorrelated with the independent variables. It will be noticed immediately that the parameters of equation (4) are none other than the productivities of different size classes of farms.

One problem with equation (4) in its present form is that, since the productivities enter the equation as coefficients, the productivity of a size class is assumed to be identical for all the districts in the

[3] The equation can be estimated only under the assumption of an i.i.d. error term. The addition of an error term to an identity such as that in equation (3) is difficult to justify on theoretical grounds, but is needed as an empirical expedient.

sample. This assumption is too restrictive, especially when dealing with an all-India sample of districts. However, if the productivity coefficients themselves are expressed as functions of some other variable, we can have the productivity of the same size class varying from district to district. In our case, we can let this variable be the level of technical change experienced by a district, so that the hypothesis of the inverse relationship weakening with technical change can also be tested simultaneously.

The estimating equations are then of the form,

$$(5)\quad Y_i = Y_{ni} + (Y_{1i} - Y_{ni})s_{1i} + (Y_{2i} - Y_{ni})s_{2i} + \ldots + (Y_{n-1\cdot i} - Y_{ni})s_{n-1\cdot i} + v_i,$$

$$(6)\quad Y_{ki} = a_k + b_k I_i,$$

where $k = 1, 2, \ldots, n$, and I_i is the variable inducing a continuous shift in the productivities of each size class of farms. Equations (5) and (6) collapse into a single equation, estimable by ordinary least squares:

$$(7)\quad Y_i = a_n + b_n I_i + (a_1 - a_n)s_{1i} + (b_1 - b_n)s_{1i}I_i + (a_2 - a_n)s_{2i} + (b_2 - b_n)s_{2i}I_i + \ldots + (a_{n-1} - a_n)s_{n-1\cdot i} + (b_{n-1} - b_n)s_{n-1\cdot i}I_i + v_i.$$

Once equation (7) is estimated and the a and b coefficients obtained, we can apply the formula in equation (6) to get the technology-specific productivities of each size class of farms.

Application

Data for 272 districts have been used to estimate equation (7).[4] The data are for the agricultural year 1970–71, except in the case of average district productivity per hectare, which is averaged over three years (1969–70, 1970–71, and 1971–72) to eliminate short-term fluctuations arising because of abnormal weather. In calculating district output, constant all-India prices have been used to value each crop.

The variables used in the analysis are defined, and their means and standard deviations reported, in table 1. Two things will be noticed from this table: first, size classes have been defined in terms of size quintiles of farms. This circumvents the problem of comparability of acre- or hectare-defined farm sizes across heterogenous regions, and allows us to define categories that transcend regional boundaries.

Second, average fertilizer application per hectare has been used as a proxy for technical change in agriculture. This is because chemical fertilizers, along with the high-yielding varieties (HYVs) of seeds, have been mainly responsible for the vast increases in yields that have come to be known as the Green Revolution. Because of the very high degree of complementarity between HYV seeds, fertilizers, and irrigation, any one, rather than a composite index of all, of these factors can be used as a proxy for technical progress.

The OLS regression results are reported in table 2. Using the formula in equation (6), predicted group- and technology-specific productivities have been computed from the raw regression coefficients. These are shown in table 3. Additionally, tests of significance on linear combinations of the estimated coefficients have been performed to test hypotheses of no difference between the productivities of various groups of farms operating at the same level of technology. The results of these tests are also reported in table 3.

The results tend to confirm the two hypotheses mentioned earlier. At the level of technology represented by no fertilizer use (shown in the first row of table 3), the smallest two quintiles of farms have significantly higher yields per hectare than the medium and the large farms. On the other hand, at higher levels of technology (shown in the lower rows of table 3), the large farm sector is significantly more productive than the medium farm sector, which in turn is significantly more productive than the small farm sector. Not surprisingly, each size-group of farms shows greater yields per

[4] The data have been compiled from a number of aggregate data sources, including the various state reports of the *Agricultural Census of India 1970–71* (for data on the size distribution of holdings), a joint Nehru University-Planning Commission study entitled *Foodgrains Growth: A Districtwise Study* (for data on average district productivities), and *Fertilizer Statistics 1972* (for data on fertilizer use).

Table 1. Variable Dictionary and Sample Means, Indian Districts, 1970–71

Variables	Definition	Mean	Standard Deviation
OUTPGH	Gross value of output (of 22 major crops valued at constant prices) per hectare of cropped area	1,005.99	491.73
*SHARE*12	Share of smallest two quintiles of farms in total cultivated area	0.095	0.039
*SHARE*34	Share of third and fourth quintiles of farms in total cultivated area	0.330	0.059
*SHARE*5	Share of largest quintile of farms in total cultivated area	0.575	0.077
FERTPGH	Per-hectare application of all chemical fertilizers (in kilograms)	18.6	21.4

Table 2. OLS Regression Coefficients, Indian Districts, 1970–71 Dependent Variable: OUTPGH

Independent Variable	Parameter Estimate	Standard Error	*T*-Ratio	Prob > |*T*|
INTERCEPT	872.302	208.236	4.189	0.0001
*SHARE*12	27.925	7.084	3.942	0.0001
*SHARE*12*FERTPGH*	−2.046	0.381	−5.375	0.0001
*SHARE*34	−12.007	5.817	−2.064	0.0400
*SHARE*34*FERTPGH*	−0.095	0.146	−0.647	0.5180
FERTPGH	36.229	6.610	5.481	0.0001
R^2	0.437			
F Ratio	41.35			0.0001
df	266			

NOTE: All variables have been defined in table 1.

hectare at higher levels of agricultural technology than at lower levels, confirming the expectation that technical change in agriculture dramatically increases the productivity of land. The fact that the productivity of the large farm sector increases by a wider margin than that of the small farm sector suggests that the gains of technological change accrue disproportionately to the former.

Conclusion

In this paper, regional data from India have been used to test the hypotheses that (*a*) the small farm sector as a whole enjoys higher yields per unit of land than the large farm sector in Indian agriculture, but (*b*) this yield-advantage of the small farm sector diminishes, and in fact even reverses, with technical change (primarily of the Green Revolution type) in agriculture. The data seem to confirm both the hypotheses.

Unfortunately, the data cannot be used to explain the change in the relative yields of the small farm sector with technical progress. On the basis of prior judgment and results from other studies, it seems that the explanation lies in the reduced importance of labor (which is possessed in abundance by the small farms) and the increased importance of cash inputs like fertilizer and improved seeds (which being credit-intensive cannot be afforded by the small farms) in determining land productivity in the post-Green Revolution period.

The policy implications of these findings are obvious. The argument that a redistribution of land from the large to the small farms will increase average yields and hence agricultural output cannot be extended to an agriculture experiencing technical change. Instead, policies which allow small farms to obtain credit easily and thus use the new agricultural technology should be stressed for productivity growth.

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Table 3. Predicted Technology-Specific Productivities of Different Size Groups of Farms, Indian Districts, 1970–71

Level of Technology (Kgs./hectare of fertilizer used in the district)	Predicted Productivities (Rupees per gross cropped hectare) Smallest 40% of farms	Next 40% of farms	Largest 20% of farms
0	900*[a]	860*	872†[b]
10	1,242*	1,222*	1,235
20	1,584	1,583*	1,597†
30	1,926*	1,944*	1,959†
40	2,268*	2,306*	2,321†
50	2,609*	2,667*	2,684†

[a] Asterisk denotes significantly different at the 0.10 level from the productivity of the next size class of farms.
[b] Dagger denotes significantly different at the 0.10 level from the productivity of the smallest 40% of farms. Predicted productivities have been calculated using the regression coefficients shown in table 2 and equation (6) in the text.

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International Farm Prices and the Social Cost of Cheap Food Policies: Comment

Yoav Kislev

The purpose of this note is to show that the prices which Peterson computed for his recent paper also can be viewed as effective exchange rates. Deviations from the world relative price system in agriculture are usually the result of market intervention, taxes, or subsidies. Such distortions, whether they are the result of domestic or of trade policies, can be viewed as distortions in effective exchange rates. For international comparisons, the exchange rate view is, analytically and conceptually, more general and convenient.

Peterson's wheat equivalent price, $\hat{p}_i$ for the commodity i, is defined as

$$\hat{p}_i = p_i(\bar{p}_w/\bar{p}_i), \tag{1}$$

where p_i is the local currency farm price of the commodity i; $\bar{p}_i$ and $\bar{p}_w$ are, respectively, the world dollar price of the commodity and wheat. The prices $\hat{p}_i$ are expressed in local currencies and calculated for each commodity in every country (the country index is omitted here).

The aggregate overall average output price for each country is

$$P = \Sigma \hat{p}_i w_i, \tag{2}$$

where the weights are $w_i = (\bar{p}_i q_i)/(\Sigma \bar{p}_i q_i)$, with q_i being the quantity of commodity i.

Equation (2) can be rewritten as

$$\begin{aligned} P &= \bar{p}_w \Sigma (p_i/\bar{p}_i) w_i, \\ &= \bar{p}_w E \end{aligned} \tag{2'}$$

The dimension of E is local currency per dollar. Thus, it is the effective farm product exchange rate. E is the value in local currency of the quantity of a composite bundle of domestic farm products that will fetch one dollar on world markets.

Peterson defined the real price as P/p_f—output price divided by the country's local price of fertilizers. Comparing countries, we are interested in price differences or ratios of real prices. In such ratios, world prices cancel out, and we can write the real prices as

$$\begin{aligned} R &= (\bar{p}_f/\bar{p}_w)(P/p_f), \\ &= E\,\frac{\bar{p}_f}{p_f}, \end{aligned} \tag{3}$$

where $\bar{p}_f$ is the world dollar price of fertilizers. If one views, with Peterson, cross-country differences in fertilizer prices as representing differences in the average price of production factors, then $p_f/\bar{p}_f$ is the effective exchange rate in the farm input market.

In equation (3), R explicitly reflects the agricultural exchange rate. Differences between countries in their R values are due to effective exchange rate distortions in the product and in the factor markets. Therefore, Peterson's supply equation can be interpreted more generally as a response function to effective exchange rate distortions. These distortions reflect market interventions stemming from both domestic and trade policies.

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The Value of Unrealized Farm Land Capital Gains: Comment

Ross G. Drynan and Ian D. Hodge

Plaxico and Kletke (PK) presented three alternative models for valuing farmland capital gains. Their first model assessed the present value of anticipated capital gains, assuming that they have value only when the asset is sold. Their second model viewed the value of unrealized capital gains as equivalent to a tax-deferred income stream with the tax being paid at capital gains rates either when the property is sold or at the end of the planning horizon. Their third model assessed the value of the capital gains as an equity base for further credit.

Dunford has criticized PK's formulations, especially their second model. However, his alternative model perpetuates several errors made by PK. Other errors made by PK led them to an important conclusion about tax rate effects, which conflicts with conventional wisdom. In this comment we correct the models for these errors and offer some further thoughts on the assessment of the value of farmland capital gains.

Dunford correctly comments that, "because the capital gains on the farmland are not actually realized until year n, it is necessary to borrow for additional investments." The value of unrealized capital gains will depend on how the increased equity base is used in borrowing more funds and how the borrowed funds are invested. There are two possibilities. One is that each year's capital gain is used as a basis for a one-year investment. Second, the gain can be the basis of an investment lasting for the whole planning horizon. The latter is equivalent to using the total accumulated value of capital gains each year as an equity base for an investment lasting one year. These two possibilities conform to Dunford's equations (2′) and (3), respectively, equation (3) being identical to PK's third model. Since the first of these alternatives appears distinctly inferior, we concentrate on the latter.

What these authors have failed to note is that it is only possible to use an unrealized capital gain as an equity base for an investment in periods after the gain occurs. All the models suggested by PK and Dunford for valuing unrealized capital gains imply that the farmland owner can borrow at the start of each year against the expected capital gain in that year. This is clearly not tenable and leads to an overestimation of the gains of about 5%.

PK err further in the way in which they include tax and inflation in their models. The present value of any future cash sum can be calculated either by discounting the nominal sum with a nominal discount rate to year 0, or by discounting the real value, measured in year 0 dollars, of the cash sum by the real discount rate. Both methods necessarily lead to the same present value. For example, a future sum S_n, when discounted at a nominal rate N, has a present value

$$PV = S_n/(1 + N)^n.$$

With discounting in real terms, the future sum becomes $S_n/(1 + Z)^n$, where Z is the inflation rate. The real discount rate R is directly related to the nominal rate, and is defined by

$$1 + R = (1 + N)/(1 + Z).$$

The present value is

$$PV = S_n/[(1 + Z)^n(1 + R)^n].$$

When substitution is made for $(1 + R)$, all factors involving Z cancel, producing the nominal analysis formula. Inflation may nevertheless still affect the present value through any effect it has on the nominal discount rate. However, as argued by Dunford, it is only if the real discount rate is used in the formula that the inflation rate will also appear.

PK include tax explicitly in their formula, effectively defining $D(1 - T)$ as an after-tax discount rate. With D defined as a real discount rate, this tax adjustment is appropriate only if D is a before-tax real opportunity cost and if tax is levied on real income. When taxes are levied on nominal income, as is usual, the real after-tax opportunity cost or discount rate R is defined by

$$1 + R = [1 + N(1 - T)]/(1 + Z).$$

When D is not simply the before-tax opportunity cost, the effect of tax on the discount rate is unclear and unlikely to be the simple proportionate reduction assumed.

It is our contention that PK's models would best be amended by deleting all explicit reference to the inflation rate, and by defining D as the nominal before-tax opportunity cost. Their third model then becomes

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Table 1. Estimates of the Value of Capital Gain for Plaxico and Kletke's Models

	Rate of Land Increase							
	5%				10%			
	Tax Rate							
	15%		40%		15%		40%	
	Discount Rate							
	12%	18%	12%	18%	12%	18%	12%	18%
10-Year planning horizon								
Model I	22024	14009	25102	18041	55814	35503	63615	45720
Model III	25286	21187	27899	24692	63231	51723	69997	60833
20-Year planning horizon								
Model I	21921	8869	32926	17007	75940	30726	114067	58920
Model III	30892	24612	41925	34775	100014	71648	138669	106417

Note: 9% interest rate is assumed.

$$(1)\quad V_2 = \sum_{i=2}^{n} \frac{(P_{i-1} - P_o)(B)(D - r)(1 - T)}{[1 + D(1 - T)]^i} + \frac{(P_n - P_o)(1 - T_c)}{[1 + D(1 - T)]^n},$$

where all other terms retain the meanings given by PK.

PK arrived at a false conclusion about the effect of marginal tax rates on an individual's competitive position in the land market. This can be measured by the individual's present value of land investment. The value of capital gains does not directly measure this present value. However, if two individuals are equally competitive in the absence of capital gains, then, when capital gains do occur, the individual with the greater value of capital gains is necessarily more competitive. We have no quarrel with the assumption of initial equality implicit in PK's comparisons. But they have made a critical error in their calculation of the present values of capital gains with high tax rates. They have, in fact, failed to adjust their discount rate for the higher tax rate (40%). PK's reported calculations show a consistent pattern of lower values for this higher marginal tax rate, suggesting the low rate individual is advantaged by capital gains, a result which conflicts with conventional wisdom about this matter. However, when corrected, the values are in fact consistently higher than those for the lower (15%) marginal tax rate, implying a competitive advantage for the individual with the higher marginal tax rate. We report the corrected values of capital gains in table 1.

PK add a further source of confusion in their note to table 2, where they indicate that they have incorporated "two inflation rates." This conflicts with their earlier comment that "the impact of inflation is ignored" (p. 328). The two inflation rates presumably refer to the two rates of land price increase which they have used.

A number of other issues arise out of PK's paper and Dunford's comment. Is it sensible to isolate and separately value the capital gains component from other components of land investment? What are reasonable *ceteris paribus* conditions for valuing capital gains? Is it, for example, reasonable to assume that the rent earned by land is independent of capital gains? Can the discount rate and the initial price P_0 be assumed to be unaffected by capital gains? If not, the valuation models presented so far will need considerably more development. These are complicated issues deserving greater attention than they have received so far.

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The Value of Unrealized Farm Land Capital Gains: Reply

James S. Plaxico and Darrel D. Kletke

The major thrust of our original paper was an exploration of alternative approaches to the evaluation of unrealized farm land capital gains (1979). Drynan and Hodge (DH) raise several important questions regarding the formulation of our Model III and point out an error in some of the computations. Unfortunately, DH, like Dunford, did not properly identify the essential difference in the conceptual bases of our Models II and III. Thus, DH do not comment on the central ideas of our paper. Our Model II is, in effect, a wealth approach to value, while our Model III is an income approach to value. This distinction is emphasized in our response to the Dunford comment (1980).

Our models are discrete on an annual basis. DH correctly point out a model error which allows capital gains to be utilized in the year of occurrence. However, gains are continuous, and although we overstate benefits, the error is not as significant as implied by DH.

Tax Adjustments

Our discount rate (D) is in real, not nominal, terms and is the opportunity cost of capital to the individual (firm) for assets that are comparable in terms of risk and uncertainty. D is a required internal rate of return (RIRR) specified by the investor and should not be confused with the average rate of return experienced by landowners. DH correctly point out that taxes are levied on nominal, not real, income. However, in our models, all tax payment adjustments are made in the income (value) stream components. That is, we tax adjust a flow of nominal income (value). We tax adjust D in the denominator only to obtain an after-tax, real discount rate (RIRR). We, in turn, convert this to a nominal rate to discount a nominal stream of benefits.

Upon reflection, precipitated by DH comments, we conclude that D should be defined in after-tax terms in lieu of tax adjusting a pre-tax D. This would permit direct comparison of the impact of the tax rate for a given real after-tax discount rate. Models are constructed to reflect (simulate) perceived reality. We suspect that investors think in terms of a real after-tax RIRR, not in terms of a before-tax RIRR. If this is in fact the case, it is not correct to interpret the results in our table 2, nor those in DH table 1, as a proper reflection of the impact of the tax rate for a given discount rate. This is the case because both data sets reflect the implications of the tax rate given the same pre-tax, not after-tax, discount rate.

Capital Gain Values, Tax Rates, and Inflation

The impact of the marginal tax rate for present values and bidding potentials is clearly an important issue. Harris and Nehring examined the impact of the marginal tax rate on the bidding potential of prospective buyers. Their conclusion, as summarized by Adams (p. 540) is: ". . . note that their present value formula implies that individual valuations decrease as the marginal income tax rate rises and high income persons *ceteris paribus* bid less for farmland than do persons in lower tax brackets" (p. 540).

Adams showed that for an infinite planning horizon, the value of an income stream is independent of the tax rate, while for a finite period, a higher tax rate results in a lower bid or value. Adams did not consider the impact of tax rate on the value of capital gains. Lee and Rask (table 2), using a model similar to our Model I, report results which compare the impact of the marginal tax rate on bidding potential. Their results suggest a higher bidding potential for a zero marginal tax situation than for a 40% rate as well as a higher bidding potential for a zero capital gain rate than for a 25% rate. Ling has further examined the Harris and Nehring model and has suggested that the net effect of the marginal tax rate is uncertain, lacking information regarding the prospective buyers utility function. Finally, Ling (p. 846) concludes that the effects of a change in the marginal tax rate on farmland bid prices is far more complex than Adams has asserted.

Our model is deterministic, and a simple assumption that utility is a direct function of present values is implicit. DH are correct in stating that we made a clerical error in computing our table 2 by failing to adjust the discount rate for the higher (40%) tax bracket assumption. That is, we adjusted all rates for a 15% tax rate. This led to the conclusion that, other things equal, higher capital gain values are associated with lower income tax rates. The DH

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computed numbers show the opposite. We have recomputed our table 2, defining D as a real after-tax rate. Again, other things equal, higher capital gains values are associated with lower tax rates. Thus, it seems appropriate to conclude that (*a*) for equal after-tax discount rates, other things equal, higher capital gains values are associated with lower tax rates, (*b*) for equal before-tax discount rates, other things equal, higher capital gains values are associated with higher tax rates. It is our conclusion that the appropriate analysis is the impact of the tax rate given equal after-tax discount rates.

DH contend that our models could be improved by deleting explicit reference to the inflation rate and by defining D in nominal terms. We elected to work in terms of real discount rates adjusted for inflation in order to examine the implications of different discount rates and different inflation rates.

Summary

In summary, the DH comments caused us to rethink our formulations. We sincerely appreciate their important contributions. We also are pleased to have an opportunity to extend, adjust, and clarify our arguments. DH question the relevance of evaluating capital gains in isolation. Much remains to be done in the area. However, a modest effort to incorporate capital gains models into a more general land value model is contained in Kletke and Plaxico (1978). The model has been presented as a time share computer algorithm, giving the user control of the relevant variables (Kletke and Plaxico 1979). Analyses based on the general land-value model show that meaningful bidding potential estimates must reflect cash flow constraints including possible cash flow deficits.

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prime rate) return on assets in both food processing and in all manufacturing has fallen decidedly over the past twenty-five years (table 1A). During the past decade, return on assets was below the prime rate for both all-manufacturing and food processing. Further, the return on assets in all manufacturing was consistently above the return on assets in food processing.

The opportunity cost of equity capital is several percentage points above the opportunity cost of loan capital (Malkiel). However, again for illustrative purposes, we will use the prime rate to adjust return on equity. The adjusted return on equity in food processing declined by around 10% between the 1950s and 1970s, but did increase by around 12% between the 1960s and 1970s (table 1B). Certainly there was not a real "50% increase in return on equity over the past quarter century" (Parker and Connor, p. 627). The relatively constant, or modestly decreasing, return on equity was obtained with substantially increased risks due to increased leverage through time.

With decreasing real return on assets and constant, or modestly decreasing, return on equity, the net social costs of profits in the food industry undoubtedly have declined significantly over the past thirty years.

Parker and Connor's choice of the year 1975 as the time period was fortuitous for their hypothesis, because the undeflated profit levels they used were among the highest in thirty years. However, real or deflated profit levels were among the lowest in thirty years.

In their empirical analysis, Parker and Connor apply three different approaches to calculating consumer loss caused by the operation of the U.S. food-manufacturing industries. We will look at each in turn in terms of underlying assumptions, methodology, and empirical estimates.

The loss-components estimates are based on an "iffy" and "subjective" method used by Scherer. Explicitly assumed is that "a competitive profit rate was for an industry with 40% four-firm concentration, equal market shares among the top four and a media advertising-to-sales ratio of .05%" (Parker and Connor, p. 630). All of manufacturing, according to Parker and Connor has a weighted four-firm concentration ratio (CR-4) of 44%, or 10% above the assumed competitive standard of 40%. However, food manufacturing's CR-4 is 52%, which is 30% above the competitive standard, or three times the rest of manufacturing. Since Scherer found an X-inefficiency loss of 3.1% of value added for all manufacturing, Parker and Connor assumed that the X-inefficiency loss in food manufacturing was 9.3% of valued added (see their table 1, type of loss 3).

It is doubtful that X-inefficiency losses increase linearly as their method implies when CR-4 for an industry increases. For example, applying this method to the data for twenty major industry groups in the original working paper on which the Parker and Connor *Journal* article was based, yields X-inefficiency type three losses of 7.3%, a serious overestimate compared to Scherer's original 3.1% estimate. In addition, their results are highly sensitive to the competitive standard they assumed for CR-4. If the true value of the competitive CR-4 lay within plus or minus three percentage points of their point estimate, calculated consumer loss from

Table 1. Prime Interest Rate, Undeflated Return and Equity, 1950–79

A. Return on Assets	Prime Rate of Interest[a]	Food Processing[b]	All Manufacturing[b]	Food Processing	All Manufacturing
	(%)	(Undeflated % Return on Assets)		(Return on Assets Minus the Prime Rate)	
1950–54	2.7	5.9	7.7	3.2	5.0
1955–59	3.9	6.2	7.3	2.3	3.4
1960–64	4.5	5.8	6.4	1.3	1.9
1965–69	6.0	6.3	7.1	.3	1.1
1970–74	7.6	6.1	6.2	−1.5	−1.4
1975–79	8.6	7.2	7.6	−1.4	−1.0
B Return on Equity					
		(Undeflated % Return on Equity)		(Return on Equity Minus the Prime Rate)	
1950–54	2.7	8.9	12.1	6.2	9.4
1955–59	3.9	9.6	11.2	5.7	7.3
1960–64	4.5	9.1	10.0	4.6	5.5
1965–69	6.0	10.9	12.6	4.9	6.6
1970–74	7.6	12.6	11.5	5.0	3.9
1975–79	8.6	14.3	14.3	5.7	5.7

[a] U.S. Federal Reserve System, Board of Governors.
[b] Federal Trade Commission.

X-inefficiency could range from \$3,200 to \$13,414 million, versus the Parker and Connor estimate of \$4,480 million. Further, as the competitive CR-4 approaches 44%, their multiplicand approaches infinity, a grossly different result from the one they have arbitrarily chosen (figure 1).

In the price-cost margin approach to measuring consumer loss, price-cost margins (PCMs) are regressed on a measure of concentration (CR-4) and other variables. The authors then use the resulting equation to predict what PCM would be for each industry at their assumed competitive level of concentration, CR-4 = 40%, and with all other variables held constant. The differences between the actual PCM and this projection is then considered the consumer overcharge.

The authors in fact present three alternative equations based on the original Collins-Preston model and claim to derive reassurance from the closeness of the results. For the first two equations which included a quadratic term for CR-4, it was possible to estimate that level of CR-4 which would minimize PCM. For equation (1) it was 19.6%; for equation (2) it was 195.4% (clearly a nonsensical result). Even in equation (1), only the squared CR-4 term was significant at the 5% level. When we checked the sensitivity of the results to errors in estimates of the coefficients we found that if the true value of the coefficients of the CR-4 variable lay within plus or minus one standard error of the reported point estimates, then the true value of the lowest PCM could occur for a range of CR-4 from 4.7% to 46.3%. Thus the findings appear not to be robust.

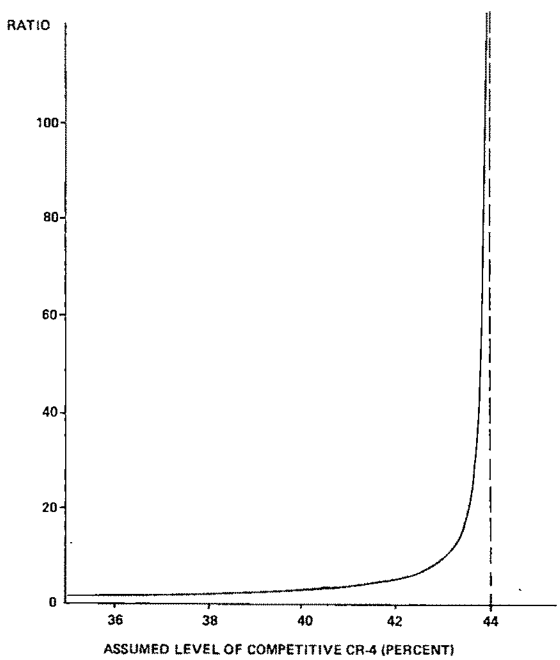

Figure 1. Estimated ratio of excess concentration in food manufacturing to excess concentration in all-manufacturing, using Parker and Connor method for different assumed levels of competitive CR-4

Equation (3) had no nonlinear term for CR-4, but the inclusion of linear and nonlinear variables for advertising as a percentage of sales of the four largest firms in each industry (ADS-4) enables us to estimate that PCM is maximized when ADS-4 equals 11%, twenty-two times the competitive value of ADS-4 used by Parker and Connor in estimating overcharges. Thus the arbitrary competitive value of ADS-4 assumed by Parker and Connor appears low. Only six of forty-one industries exceeded half that maximizing level in 1975, and only fourteen exceeded one quarter that level. Thus we are left with a paradox—if advertising is the key to monopoly profits, why do not food manufacturers spend proportionately more on advertising?

Parker and Connor apply sensitivity analysis to the choice of the competitive level of CR-4 in their PCM analysis, but not the variation of other estimated coefficients which would have proved more susceptible to small changes in value.

Parker and Connor's third approach to measuring consumer loss, which they call their "National Brand—Private Label Price Difference Estimate," assumes that private label merchandise is identical in quality to manufacturer brand merchandise. "Prices of food-chain private labels are considered to approximate competitive prices; the amounts by which manufacturer brand prices exceed private label prices for the same items and which can be attributed to departures from perfect competition are considered to be estimates of monopoly overcharges" (p. 633). As justification for this approach, Parker and Connor assume "that national brands sell at premiums which manufactures set in accordance with the strength of preference created by advertising and other promotion" (p. 634).

The authors ignore the large body of literature on quality competition per se (for a starting point, see Abbott). They ignore the problems of interpretation of physical quality measures. For example, Jafri and Lifferth's 1977 study found an average viscosity of national brand canned applesauce in terms of centimeters of flow per unit of time of 4.6917 versus 5.4167 for private brands. But this begs the question whether the highest quality would be represented by a viscosity measure above, below, or between those levels. Because most products possess a number of physical characteristics, the problem of determining "best" quality or best value for money becomes extremely complex, if determinate at all except in terms of consumer responses in the market. Finally, the identification of quality in terms of physical properties of a product ignores the role of consumer perceptions of quality in determining purchase and consumption behavior and the more fundamental philosophical question whether or not products are different because consumers perceive them to be different.

The set of assumptions put forward by the authors is only one, and by no means the most plausible, explanation of the relationship between private label and manufacturer brand merchandise. For example, Handy and Padberg report that what they call "core distributors," the ten largest retail food chains, dominate both manufacture and sale of private-label products. Core manufacturers, defined as the 100 largest food processors, dominate the manufacture and sale of specialized consumer products. On the other hand, fringe (all other) distributors not in the core group specialize in more effective performance at the retail level, while fringe processors "rely heavily on the private label programs of wholesalers and retailers for market outlets" (p. 185).

These two major foci of power seek consumer attention and patronage in different ways. "The manufacturing oligopoly stresses product development and is clearly more adept at this function than the distribution oligopoly. The latter is able to dominate the terms of trade for standard products and merchandise them to the public with an economy emphasis through extensive private-label programs" (Handy and Padberg, p. 184). "Oligopoly core manufacturers tend to work most directly with fringe distributors. This combination constitutes a channel that emphasizes innovation and progress as regards the character of the product and services . . . Oligopoly core distributors tend to emphasize private label programs; hence they are best served by the fringe processors" (p. 183).

Thus, a firm's strategy on manufacture or distribution of branded or private label products can be viewed as a rational response to its desire for survival and growth in its existing competitive environment. In this context, it is difficult to argue that private-label prices approximate the competitive norm, and that the differences between national brand and private-label prices are an unambiguous basis for measuring overcharges due to monopoly. Indeed, it seems conceptually inappropriate to explain differences between brand and private-label price as due to the structure of the food-processing industry without taking account of the structure of retailing and the interaction between processors and retailers.

However, Parker and Connor choose to do so. Essentially, they explain the price difference between branded and private label items of the same product in terms of variables used in their first two approaches, four-firm concentration, advertising, a geographic-market index, and a variable for industry growth, with the addition of three further variables to represent volume of sales by product class (*LNSIZE*), number of firms (*LNFIRMS*) and net imports (*NETIMP*). They used no less than three separate advertising variables and, in all, ten explanatory variables. Clearly, their final functional form was based on ad hoc rationalizations, rather than on a tested, coherent theory of the process being modeled. Thus, one may question the appropriateness of the final equation chosen. For example, if CR-4 had been represented by a linear term and ADS-4 by a quadratic term, as in Parker and Connor's equation (3), would signs, magnitudes, or significance of coefficients have been altered? And if the variables, *LNSIZE*, *LNFIRMS*, and *NETIMP* help to explain monopolistic price differences (*DIFF*), should they not also have been used to explain monopolistic price cost margins (*PCM*) in equation (3)?

Having presented three separate approaches to measurement of consumer loss, the final plank in Parker and Connor's argument is that "the extent of convergence of all three essentially independent estimates gives strength to the conclusion that consumer loss due to monopoly in the U.S. food-manufacturing industries in 1975 was at least $10 billion, but possibly as high as $15 billion" (p. 637) [or from 1.9 to 2.9 times total profits in the industry for 1975].[1] However, we have shown that their loss components estimate explodes if the competitive CR-4 approaches 44% and varies widely for small deviations around their assumption that CR-4 equals 40%. Their estimate based on the price-cost margin method is sensitive to variance in the estimated parameters. Their national brand-private label price difference estimate ignores the structural interaction of food processors and retailers and relies on a functional form indistinguishable from thousands of others, equally plausible. Thus, convergence rests on specific arbitrary assumptions chosen by the authors and not on the industry's unique "monopolistic" characteristics.

The authors call for stepped-up antitrust activity including limiting advertising, stricter policies on product extension mergers, and even divestiture of physical assets of leading firms and compulsory licensing of major trademarks. This recommendation to alter significantly the structure of the food-manufacturing industries is not justified by the data presented. Even if the analyses were based on solidly realistic assumptions and if the methodologies were sound, precise, and unquestionable, their recommendations would not necessarily follow. The authors ignore any possible losses in efficiency from restructuring. These efficiencies are an integral part of structure considerations (Greig). For example, in comparing alternative industrial structures McGee states, "A proper standard involves efficiency considerations . . . it is a question of fact whether efficiencies of large firms have been or will be generated, relative to other industrial structures" (p. 135); and Weston argues, "In summary, recent evidence runs against the view that concentration in the U.S. is higher than need be for efficiency" (p. 626). Parker and Connor present no evidence that the social returns from their reorgani-

[1] Department of Commerce data suggest total corporate profits in food processing in 1975 to be around $5.2 billion, while Internal Revenue Service data suggest corporate profits to be around $4.1 billion.

zation of food manufacturing industries would be greater than the social cost.

Parker and Connor have made an heroic attempt to quantify an elusive concept. Their approaches will be valuable to future researchers who keep in mind the limitations we have highlighted. In addition, while researchers undoubtedly will continue to study whether or not there is consumer loss due to market imperfections in food manufacturing, we have tried to show that researchers ought also to be concerned about the falling real return on assets and on equity in all U.S. manufacturing and in food manufacturing.

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Estimates of Consumer Loss Due to Monopoly in the U.S. Food-Manufacturing Industries: Comment

J. Bruce Bullock

In a paper published in the November 1979, issue of the *American Journal of Agricultural Economics*, Parker and Connor conclude "that consumer loss due to monopoly in the U.S. food-manufacturing industries in 1975 was at least $10 billion, but possibly as high as $15 billion" (p. 637). The authors suggest that their findings provide justification for expanding the budgets of U.S. antitrust agencies and for restructuring the industry.

Parker and Connor (PC) have provided only part of the information required to draw these conclusions. Therefore, the results of their study do not provide justification for either expanding the antitrust agencies or restructuring the U.S. food-processing industry. Indeed, it is quite possible that restructuring the industry toward a more atomistic structure would be contrary to the public interest. The relevant question is not, how much monopoly profit exists in the food-processing industry? Rather, the relevant questions are: (*a*) does an alternative industry structure exist that will provide more net consumer welfare with no increase in resource use? and (*b*) how can the change to the "preferred" structure be accomplished and what will be the cost? Parker and Connor have not answered these questions.

The monopoly overcharge rectangle as defined by PC is illustrated in figure 1, assuming a linear demand curve DD and constant average cost curves; C_a represents the cost curve if the industry has an atomistic structure. Parker and Connor postulate that the costs of firms in the oligopolistically structured industry (C_1) are above the costs that would exist in an atomistically structured industry. The monopoly price P_1 thus extracts monopoly overcharges of P_1AFC_a from customers. "Just how much of the overcharge rectangle P_1AFC_a is an income gain to the monopolistic depends on how much higher the monopolist's average costs (C_1) are compared to the competitive level C_a" (Parker and Connor, p. 628).

What evidence do we have that the monopolists' costs are higher than the costs of more atomistically sized firms? Changes in the number and size of firms in the industry over the past twenty-five years strongly indicate that the costs of these larger firms are lower than the costs of the firms they replaced. How could higher-cost firms have replaced lower-cost firms? The current structure could have evolved only because the costs of the larger firms are below those of smaller firms that exited the industry. Apparently, the oligopolistic firms provided consumers with lower priced (or perhaps higher quality) products—not just on a short-term "predatory" basis, but over a prolonged period of time under wide-ranging economic conditions; to argue that the costs of the oligopolistic firms are higher than the costs that would exist in a more atomistic structure (for the same quality product) is to ignore the economic reality of what has happened in the past twenty-five years. It does not matter whether the firms grew through internal expansion or through acquisition. The fact remains that the larger firms could survive while smaller firms exited the industry only if the costs of the larger firms are lower than costs of smaller firms.

The observed structural changes over the past twenty-five years suggest an alternative analytical framework may be more appropriate for evaluating the social desirability of the current structure of the U.S. food industry. As noted above, evidence provided by the marketplace strongly suggests that the costs for the oligopolistic industry are below the costs that would exist in a more atomistic industry, say, level C_2. The oligopolistic market price in this situation will be somewhere between C_2 and C_a, for example, P_2. Monopoly rents in this situation are therefore represented by the area P_2HJC_2 in figure 1. This is the area which PC estimated to have been $12.5 billion in 1975 (midpoint of their range). While $12.5 billion sounds like a lot of money, it amounts to only about $1 per person per week—hardly more than rounding error in the consumer's food budget.

Greig points out that there are social costs of atomistic competition. "Because the atomistic markets approach the 'perfect' markets in numbers and size of firms, some seem to assume that atomistic markets operate with few or no social costs. However, if the costs to society of imperfections in the atomistic markets were compared to imperfections in the segment having market power, then by far the greater social costs would be in atomistic markets. The lack of knowledge of potential supplies and potential demands, unnecessary risk and uncertainty, lack of knowledge and lack of optimum scale, excess capacity, mislocations, cross-

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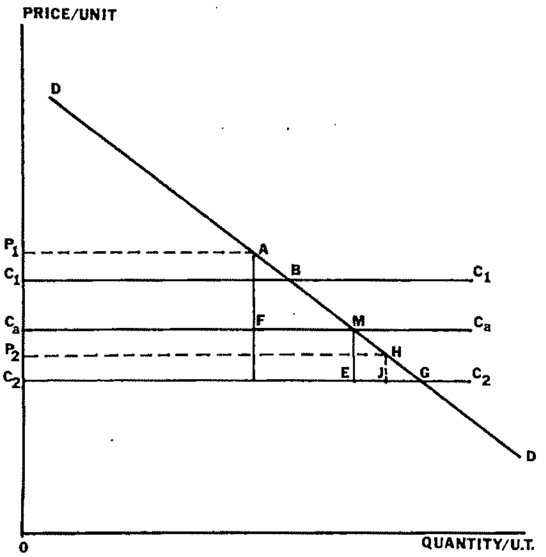

Figure 1. Illustration of Possible Impacts on Consumer Welfare: Oligopolistic vs Atomistic Industry Structure

food markets considerably outweigh the social cost of market power" (p. 27).

The social cost of atomistic competition is represented by area C_aC_2JHM in figure 1 ignoring (as PC did) the resource allocation dimension of monopoly pricing.[1] (Note that the allocative inefficiencies under an atomistic structure [*MGE*] are larger than under the oligopolistic structure [*HJG*].) Because the social costs of atomistic competition exceed monopoly rents in this situation, consumers are better off with an oligopolistic structure than with an atomistic industry structure. This will be the case any time that production costs of the oligopolistic structure are below those that would exist in an atomistic structure, and monopoly powers are not exercised to the point that a price above C_a is extracted from consumers. The economic incentive of oligopolists will be to charge a price below C_a so as not to attract competition. Moreover, rivalry between oligopoly firms will keep returns competitive with other segments of the economy. How can monopoly profits exist if resources earn no more than their opportunity cost? Thus, the $12.5 billion "monopoly overcharge" estimated by PC may be a quite acceptable price to pay for the consumer benefits (area C_aC_2JHM minus the area P_2HJC_2 in figure 1) generated by an industry structure that enables firms to take advantage of economies of size, achieve better coordination, reduce risk, and make investments in new product development.

Unfortunately, there are several value judgments expressed in the PC paper that detract from its usefulness as an objective and scholarly analysis. For example, in trying to convince the reader that monopoly firms have higher costs than competitive firms, Parker and Connor state that "monopoly firms often allow managerial withdrawals in the form of fancy offices, corporate jets, and other inessential perquisites" (p. 628). This leaves the authors in the untenable position of trying to answer the following questions: What distinguishes a "fancy" office from an adequate-but-not-fancy office? Are corporate jets always unsound business investments? What is the difference between an inessential and an essential perquisite? For example, is the civil service retirement system for government employees (such as Parker and Connor) an essential or inessential perquisite?

Parker and Connor mistakenly conclude that because "monopolists do not have as strong incentives to minimize their costs of products as do competitive firms" (p. 628) the production costs of oligopoly firms will be higher than the costs of firms in an atomistic industry structure. Arguments that costs of oligopoly firms could be lower than they currently are, are perhaps true. However, such arguments are irrelevant for purposes of making judgments about the social desirability of alternative industry structures. In an economy such as ours where there are enormous economies of firm size, the production costs of oligopolistic firms may be below the costs of firms in an atomistic structure—even if the oligopolists do not produce at minimum costs.

PC place heavy emphasis on the social costs associated with oligopolistic firms use of advertising funds. They state that advertising "expenditure levels and content are not made in accordance with consumer preference; rather thay are chosen by companies to maximize advertising effectiveness. Although advertising expenditures may be efficient for this purpose, they are likely very inefficient in producing social benefits" (p. 629). Apparently PC use the term "social benefits" of advertising to refer to the entertainment value of programs sponsored by advertising expenditures. Their conclusion about the inefficiency in use of these funds seems to be at odds with reality. Presumably, consumers watch television shows they like best. Advertising agencies and the networks pay close attention to program ratings reflecting the number of viewers. Moreover, per-minute advertising rates vary directly with the current and/or projected ratings of a program. Such a pricing and advertising expenditure allocation system appears to be quite consistent with the use of advertisement funds to produce social benefits as well as maximization of

[1] A reviewer of this comment points out that this type of geometry is applicable only when one is dealing with homogenous and competing products. This points out the problems—perhaps the complete fallacy—of applying the concepts if monopoly profits to a multiproduct and product-differentiated industry such as food manufacturing. However, such a distortion is necessary if we are to address questions about the social desirability of the structure of these types of industries. The costs reflected in the cost curves of figure 1 are the total set of costs of production, product differentiation, and all other costs associated with operation of firms in the industry.

expected return on advertisement expenditures. Therefore, the production of social benefits with advertisement expenditures is inefficient (as suggested by PC) only if television viewers are incapable of determining what they enjoy watching.

The third procedure used by PC to estimate monopoly profits is to attribute the price difference between brand name and private label items to monopoly profits. Monopoly profits are extracted by restricting the options available to consumers—not by providing consumers with a free choice between alternatives.

The purchase of a brand name item by a consumer is the result of a conscious decision to select the item from a shelf containing both the brand name and private label item. Moreover, the price of each item is marked on each container and/or the shelf. The rational consumer will purchase the brand name only if its price premium is less than the consumer's perceived difference in value (utility) between the two items. Because the consumer willingly pays the price difference to acquire what is perceived as a higher quality product, it hardly seems reasonable to call the price difference monopoly profits. Rather, the price difference is a lower bound estimate of the added quality (value) of the brand name item relative to the private label item. Arguments that there really is no technical difference between the two items are irrelevant. Quality—like beauty—is in the eye of the beholder. The continued existence of price premiums between brand name and private labels is strong evidence that for some consumers (those that buy the brand name item) the higher value (utility) justifies the price differential. Thus, it is erroneous to use the price differential as a measure of monopoly profits.

The PC recommendation for restructuring the U.S. food-processing industry was a foregone conclusion given the conceptual framework used for their analysis. Use of the alternative conceptual framework (i.e., demonstrating that the oligopolistic firms' costs are at level C_1 and not level C_2 while the production costs in an atomistic structure are at level C_a) would introduce more objectivity into their analysis. This framework leaves open the possibility that the authors will arrive at the same set of recommendations. However, this framework will require that PC be much more rigorous in their analysis and that they substantiate some of the unsupported value judgments contained in the current paper. If the revised analysis leads PC to the same conclusions they will then have much more convincing evidence that the U.S. food-processing industry should be restructured.

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Estimates of Consumer Loss Due to Monopoly in the U.S. Food-Manufacturing Industries: Reply

Russell C. Parker and John M. Connor

We appreciate this opportunity to respond to these two comments. Our article presented three independent estimates of the loss calculated, using widely different data sets and methodological approaches. Two of the approaches used statistical models from standard works in industrial organization. The third was based on original work by the authors, using regression analysis to refine a set of brand-by-brand price and sales data uniquely available for the food industries.

Professors O'Rourke and Greig (OG) open their comment by arguing that the Parker-Connor (PC) conclusion that the food industries are imposing a social cost on consumers is highly misleading because we failed to recognize that the high and increasing profitability of food manufacturing actually represents declining "real" rates of return on assets and stockholders' equity of food-manufacturing industries. They allege that the "real" rates are below the opportunity costs of capital. Real rates of profit are defined as the actual rate of profits on total assets and on stockholders' equity relative to the prime rate of interest in the economy.

Since OG use total assets as the denominator in their rate of return, but exclude interest payment in the numerator, the values of their "real" rates of return are low. Interest payments should not be excluded because many companies borrow money, for which they pay interest, to finance part of their assets. The OG real rate of return on assets is peculiar because it is a function of the amount of borrowing as well as business success. Industrial organization studies either include interest in the numerator of the asset ratio or use profits as a percentage of stockholders' equity. The latter expresses profits such that it is easier to determine if stockholders are sufficiently rewarded to attract and maintain necessary ownership capital. It is noteworthy that the OG series of profits on equity shows essentially the same trend as that which PC reported, even after the OG deflation procedure is applied. The choice of 1975 as the terminal year did not affect the upward trend in food manufacturers' profits; any terminal year from 1970 to 1979 confirms the trend. Their ending period does not show as high a level for food manufacturers relative to all-manufacturing (table 1) as PC did, but this was primarily because of their final period capturing a relative boom in the cycle of all-manufacturing profits.

Contrary to the assertion made in the OG comment, the PC estimate of excess profits in no way depends on a fortuitous selection of the year 1975. Our estimate was based on the application of 1972 to 1975 industry structure data to a profit function fitted to data for a five-year period in the 1950s. This should also eliminate the OG concern about the effects of inflation on profits since inflation was low during the period over which the equation was fitted.

The claim that inflation causes reported rates of profitability to rise markedly above real rates is supported neither by recent empirical investigations nor, curiously, by their own citations. Fama has calculated inflation-adjusted rates of corporate profitability on assets for 1968–78. Incidentally, he also argues that the numerator should include net interest payments. The denominator should be real total capital, assets evaluated at replacement cost. Profits are adjusted downward for inflation-caused inventory profits and for underdepreciation caused by valuation of assets at historical costs. Cash flow for interest payments and depreciation has increased enormously over the 1950–78 period. Nevertheless, Fama's results indicate that average corporate profits in the 1970s were higher than those in the 1950s (8.1% versus 7.7%), though not so high as in the 1960s. Feldstein and Summers, using a similar method, also conclude that there is no evidence of a long-term fall in the rate of return to nonfinancial corporate capital, 1948–76. OG have made no such adjustments. Finally, the relevance of the Malkiel reference made by OG eludes us. Malkiel's only reference to profits is a passionate argument for corporate tax relief through depreciation-rules changes as a means of encouraging productivity.

The use of the prime interest rate as a measure of opportunity costs assumes that the value of a dollar of interest income and a dollar of after-tax accounting profit would be identical to an investor if risk were held constant. Such an assumption, however, ignores the income tax advantages with stock ownership, such as dividend exclusions and tax rates on capital gains, that are about half those applicable to interest income. It also ignores any effect that inflation has on increasing the current

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The views expressed in this Reply do not necessarily represent those of their respective agencies.

market or replacement value of physical assets owned by companies. Financial assets, which bear interest payments, do not inflate but remain fixed in terms of dollars, which decline in purchasing power during inflation. It is possible during periods of rapid inflation for investors to consider zero or even negative company profits superior to high rates of monetary income earned in the form of interest. The real income of a recipient of interest could be negative if the inflation rate exceeded the interest rate. On the other hand, if the physical productivity of a company's assets remains the same, the real wealth of their owners should tend to stay constant during inflation.

A more appropriate extension of the analysis of company profit performance on invested capital than the one offered in the comment would be to look at relative changes in stock prices, disposals of companies below their book values, failure rates of technically efficient firms, the inability of such companies to float new stock issues or to borrow needed capital, and evidence of undercapitalization. Although the present authors have not made an exhaustive study, there appears to be little evidence that food companies are failing these market tests. We see no merit in departing, as OG have done, from these more traditional economic analyses.

Excess profits were only one of the components of the cost-components approach. Excess profits were about 30% of the total consumer loss. By failing to consider the inefficiency costs of monopolies as part of the overcharge, OG imply that consumers are irrationally obsessed with industry profits. In fact, consumers should be concerned primarily about how much higher prices are costing them and only secondarily with the level of profits that monopolists are receiving.

The data on profit trends were included in our review of industry structure merely to provide a motivation for our study—circumstantial evidence that a competitive problem may exist. It is entirely possible for a high consumer overcharge to exist in industries experiencing negative profits.

The assertion by OG that we somehow "overlooked" studies pointing to small monopoly losses (e.g., those by Schwartzman and Worcester) is irrelevant because those studies are estimates of the deadweight loss only. OG are confused over the distinction between consumer loss and net social loss—a distinction we belabored in our article.

The statistical flaws OG allege are primarily rehashes of limitations already made explicit with appropriate caveats by PC. Regarding the alleged flaw in the first of the estimates, which was an estimate derived by adding together the separate estimates of individual overcharge components, the commentors apparently misread the PC article. We described Scherer's estimates, as Scherer himself did, as "iffy" and "subjective." We used the Scherer textbook only as an acceptable source for describing the components of overcharge. We did not use Scherer's estimates in computing the major components of overcharge.

The two main components, which together constituted over 60% of our total overcharge estimate and were the major factors in estimating allocative inefficiency, were estimated from data and models specific to the food-manufacturing industries. Only a third of our total estimate was an extrapolation of Scherer's estimates. In describing these extrapolations, the present authors cautioned that they were the "least reliable of our estimates" and "included mainly for heuristic reasons." OG, in a misleading fashion, focus on these latter estimates in their discussion. Lest there be no mistake, we continue to question the reliability of these extrapolations both because of the data from which they were extrapolated and the method of extrapolation. However, considering the high values estimated for the two principal components of overcharge, there would seem to be little question that there should also be a significant amount of X-inefficiency. Had Scherer's percentage for the residual X-inefficiencies been applied directly, without the questionable adjustments for the relatively higher levels of food manufacturer concentration and advertising intensity, the extrapolated values would have totalled \$1.5 billion. This would have yielded a total overcharge estimate of 9.25 billion—not far from the \$10 billion which we reported as the likely low end of the error range.

Our second overcharge estimate was based on a regression analysis of census price-cost margin data. Our estimate held constant all factors, other than competitive structure factors. The OG charge that we "arbitrarily" chose CR-4 = 40% as our workable competitive standard is disturbing. In the body of the article (Parker and Connor 1979) we cite Scherer as an authority. But several other citations are included in PC (1978, p. 67), as well as a modest analysis of the level of CR-4 justified by estimates of minimum optimal scale. This evidence and subsequent searches of the literature on the "critical" concentration ratio leave us convinced that the CR-4 = 40% is a realistic dividing line for workable competition in most national market food-manufacturing industries. We did not calculate our estimates of consumer loss against the impossibly utopian standard of atomistic competition.

The presentation of the price-cost margin section began with a brief historical development. We gave the reader the initial Collins-Preston equation (1) and a refit based on 1970s' data (eq. 2). However, our analysis advanced beyond these historical equations. We fit a third equation, incorporating the more complete specification which benefitted from research during the last decade. Our article stated that "the authors believe that the estimate from equation (3) is superior" (p. 633). Despite this statement, OG choose to level their guns exclusively on the historical equations (1) and (2) and point out nothing more than what was stated, namely, that equations (1) and (2) show substantial

"variability in overcharge amounts due to the choice of the level of concentration defined as competitive" (p. 633).

Their only criticism of the preferred equation (3) is that the maximum price-cost margin point for an industry occurs at an advertising rate of 11% on sales. They ask why food manufacturers are not spending more on advertising since a higher rate would yield more monopoly profits. Besides their inexplicable confusion between monopoly overcharge, which was the object of the regression equation, and monopoly profits, which is only one component of overcharge, their criticism assumes that all products have a maximum potential for differentiation. In fact, products have varying degrees of limitations—the nature and importance of the product, grade labeling, alternative product availability, and a number of other factors. In our analysis, each observed point is assumed to be in equilibrium with advertising applied by each firm so as to maximize its rate of return. The appropriate question that should be asked of our equation is how well does it fit the data in the relevant range, not the meaning of some point far beyond that range. If our equation describes accurately in the relevant range, then the calculated overcharge amounts should be equally accurate. By their silence on this point, one must infer that OG are satisfied with this essential characteristic of equation (3).

The third estimate of overcharge was based on a regression analysis of the price differences between private labels and national brands of consumer food products. This approach involved not only a totally different kind of dependent variable than that used in the price-cost margin approach but also afforded a much more dissaggregated level of analysis. OG criticize our disaggregation on the grounds that the SIC product class (and industry) categories often are too narrow and do not represent well-defined markets. While it is true that SIC definitions were not designed specifically to meet the requirements of industrial organization research, virtually all such econometric studies have employed SIC-based data simply because they are the best available. If anything, the consensus is that SIC 4-digit and 5-digit categories tend to be overly broad definitions of true markets (Wilcox and Shepherd 1975, p. 43). Moreover, the OG illustration of the five dairy industries (butter, cheese, canned milk, ice cream, and fluid milk) as too narrowly defined is a good example of one of their "unsupported assertions." They imply that consumer substitution is high among the five industries, thereby introducing considerable interindustry competition. The most reliable U.S. Department of Agriculture estimates of cross elasticities of demand with respect to price fail to support their view; not one of the twenty possible cross elasticities among the five dairy industries exceeded the 0.10 level (Huang). The marketplace provides further evidence that SIC food product classes are not too narrow, as claimed. Most large food manufacturers purchase data from marketing services firms like Nielsen Company, which use classifications typically narrower but highly consistent with census product classes.

O'Rourke and Greig charge that the national brand-private label model is not based on any "tested, coherent theory." A closer reading by OG of the text on page 634, for a discussion of advertising effects and page 635, for the reference to an article by Nickell and Metcalf would have provided OG the theoretical basis for including the questionable variables. Nickell and Metcalf do a rather good job of laying out a theoretical basis for explaining national brand-private label price differences; they also test an original U.K. data set using a model very similar to PC.

As well as ad hocery, the OG comment alleges that PC ignore the problems of physical and psychic quality differences between private labels and national brands. In fact, we reported the findings of all such studies we could locate, including the one by Jafri and Lifferth offered in the comment as an example. The PC discussion raised several concerns and reservations concerning the general conclusion of these studies, namely, that no significant differences in quality exist between private labels and national brands. It should be noted that the existence of quality differences per se does not weaken the PC results, not even when those quality differences are associated with higher prices. The significance of the relationships could be challenged only if quality differences were positively associated with values of those independent variables which measure the aspects of structure used to estimate overcharge. If the quality differences of national brand products of high-concentration industries (such as puffed wheat cereal by Quaker vs. private label puffed wheat cereal) were generally greater than the quality differences in low-concentration industries, such as prepared meats, then there would be an upward bias in the overcharge estimate. Even if there were such an association, the bias introduced could still be insignificant.

OG believe that we unfairly single out advertising as a source of undesirable changes in the food system. They illustrate their point with a quotation (Parker and Connor, p. 629) that is taken out of context. That sentence listed plausible impacts that lay outside the scope of our research and about which we offered no judgement. Our policy suggestions on advertising are deduced from the coefficient values of our estimating equations (3) and (3.1), as well as other cited research. OG are correct that our model considers exogenous several factors (e.g., growth of the leisure industry) that may affect aggregate food demand. However, the present authors do not see how these factors would weaken the values of the advertising coefficients or their statistical significance.

OG's final point on the private label-national brand estimate is that national brand producers carry the cost of product innovation, while private labels only follow. Thus, they say, the price differ-

ence that is observed reflects a real social cost. Let us suppose that there is such an effect and that the variable measuring product growth, which was introduced to control for this effect, did not capture it. Are there data that might indicate the magnitude of the resulting bias? National Science Foundation data show that the food and kindred product industries rank lowest except for primary metals in terms of intensity of R&D activity. Worley found, in addition, that they were the only major group of industries where R&D intensity was inversely related to company size. These data do not suggest that the brands of large national companies carry a heavy burden of product development, and therefore suggest only a small potential bias if there was, indeed, a problem with equation specification. However, this may be a useful area for future research.

Bullock's main criticism is that it is theoretically possible for consumer welfare to be higher under monopoly than under pure competition if the average costs of production and distribution are lower in the monopoly case. Of course, we agree with Bullock's exposition of this possibility because we too are familiar with the textbook discussions of it, such as the initial pages (pp. 21–22) of Scherer's (1980) textbook. And we invite Bullock to look at figure 2.4 in Scherer, which is practically identical to his figure.

The resolution of this issue requires an empirical investigation to determine whether the largest firms have costs significantly lower than their smaller rivals (what he calls "atomistically sized firms"). We do not believe the answer is quite as simple as Bullock implied with his undocumented assertion that larger food firms have "replaced" smaller ones over the last twenty-five years, and that this change has occurred only because the larger firms were always more efficient. Bullock's simple survivor analysis blurs important distinctions such as technological versus pecuniary advantages of size, plant versus multiplant economies of scale, and specialized-firm versus conglomerate strategies (Scherer et al. 1975). Even a casual examination of basic census data on labor productivity differences among food-processing plants reveals that in most industries the most efficient size class lies between the extremes, suggesting the prevalence of the traditional U-shaped average cost curve. (Total factor productivity of food-manufacturing plants is not available by size classes.) Bullock's fascination with sheer size overlooks the fact that from a competitive point of view, the relevant consideration is optimal plant size relative to the market. Because national food-manufacturing markets are so large, it is unusual for a single plant (even the largest in the industry) to account for as much as 5% of the total shipments.

Both OG and Bullock cite a bulletin by Greig, which purports to estimate costs due to atomistic competition in the food-manufacturing industries. Greig's "method" reveals an inadequate understanding of the equilibrium assumptions underlying industrial organization theory. Workable competition is always assumed to be in long-run general equilibrium; firms are assumed to be producing at their minimum optimal scales. In the atomistic state apparently envisioned by Greig, firms are so miniscule that they are producing at levels below their technological optimum.

One might also fault Greig for his misuse of basic macroeconomic concepts, as well. In his adaptation of the Scherer estimates of consumer loss due to market power in the food industries, Greig takes 6.2% of shipments in SIC-20 instead of the appropriate measure of the "contribution to GNP," value added. This exercise led to an erroneously inflated estimate of consumer loss.

Bullock further asserts that the conceptual framework for our analysis guarantees that our estimates of consumer overcharge are large and positive. Adoption of the framework implied by his figure, he states, would introduce "more objectivity" and "rigor" into the analysis. This criticism is baseless. First, the only difference between Bullock's model and ours is the relative positions of the competitive price Pc and the monopoly price Pm. However, the two econometric models we used to estimate overcharges are perfectly capable of handling positive or negative margins or price differences. In fact, had Bullock examined our SAMI data source, he would have discovered that there were several cases where average private label prices exceeded average national brand prices. Second, for several industries, our models predicted no overcharge. In principle, all the industry estimates could have been zero.

In addition, Bullock questions the theoretical assumption of our national brand-private label price difference model that these differences contain information about overcharges. To Bullock, both price difference and quality difference considerations between national brands and private labels are irrelevant. The mere fact that consumers willingly pay the price differences means that consumers are maximizing utility and suffering no loss. If consumers perceive a quality difference, that is all that counts. Underlying this criticism is an abiding faith that markets never fail to be efficient. Needless to say, Bullock's faith ignores a huge body of microeconomic and industrial organization literature, declares a major area of academic curricula in American universities obsolete, and implies that the largest identified specialty in the American economics profession is irrelevant. Aside from these small matters, it also leaves several questions unanswered. In what sense do consumers make willing choices if high search costs are necessary and if markets are subject to large expenditures on persuasive advertising? In what sense is the supracompetitive equilibrium, that theory which predicts when there are high search costs, efficient? In a more practical vein, does it not do injury to serious economic analysis to assume that physically identical products that may simultaneously come

off of the same production lines, but are branded with highly advertised labels, give 30% or more additional satisfaction? Would it not be appropriate to question whether consumer choice is adequately informed?

The Darwinian-type faith, expressed in both comments, that any structure or behavior that emerges from markets necessarily maximizes efficiency leads their authors to label the PC research, which is not based on this faith, as prejudiced. The authors of the comments require that until PC can demonstrate evidence of specific instances of food-manufacturer management laxity and list specific management perquisites not justified by efficiency, there is no basis for a model which has *X*-inefficiency as a component of consumer loss. We reject this requirement as overburdensome in light of the economic literature of the effects of monopoly. We also reject the burden required of us, especially by Bullock, that we prove the superior performance of atomistically structured food-manufacturing industries. It is obvious from our assumption that any industry with less than 40% 4-firm concentration is competitive, that we employ a workable, not atomistic, structural standard.

The short PC policy section that inflames the authors of the comments was an attempt to make modest suggestions of some of the public policy implications of our research. In drafting our discussion, we tried to touch on only those options which, in our opinion, have played the most prominent role in congressional hearings and in the antitrust literature. We reject the criticism that we should have measured the costs and benefits of each policy option before mentioning it. Our policy section discussed the likely policy significance of the size of our consumer loss estimates and of some of the estimated parameters. This limited objective was, in our opinion, consistent with the limited scope of the paper as it appeared in this *Journal*.

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Mitigating the Effects of Multicollinearity Using Exact and Stochastic Restrictions: The Case of an Aggregate Agricultural Production Function in Thailand: Comment

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Mittelhammer, Young, Tasanasanta, and Connelly in estimating an aggregate agricultural production function use a variety of techniques to deal with multicollinearity present in their sample, including exact and stochastically restricted least squares and principal components regression.[1] They claim that consideration of these techniques allowed mitigation of a serious multicollinearity problem present in their data and permitted more precise parameter estimates. The authors also hold that two of the techniques they considered "generally outperformed OLS in terms of risk and overall reasonableness . . . (p. 199). While the empirical evidence Mittelhammer et al. present is convincing and the product of sound econometrics, we feel that some important limitations of the estimation techniques they employed as alternatives to ordinary least squares (OLS) were not sufficiently stressed. Furthermore, we will provide estimators that are unambiguously superior to least squares under a variety of standard loss functions.

Problems in Achieving Precise Estimation Using Restricted Least Squares and Some Alternatives

Combining sample observations with exact or stochastic restrictions has the effect of reducing estimator sampling variability relative to that of OLS. Even if the restrictions are incorrect (or biased in the case of stochastic restrictions), implying that the restricted least-squares (RLS) estimator is biased, the mean square error or risk of the RLS estimator may be less than that of OLS. Unfortunately, the potential risk gain occurs only over a relatively small portion of the parameter space where the restrictions are close to being correct (where the meaning of "close" depends on the risk function adopted). Furthermore, RLS estimators have risk functions that are unbounded in the sense that the further the restrictions are from being true, the greater the risk of the estimator. Thus, while it is true that RLS estimators have smaller risk than OLS under appropriate conditions, those conditions depend upon the true parameter values, which are unknown. Consequently, when using exact or stochastic restrictions, the researcher never knows whether a risk improvement over OLS under standard loss functions is realized.

Because the true parameter values are unknown, a common practice is to test statistically whether RLS is preferred to OLS under one of the standard risk functions described by Mittelhammer et al. and use the RLS estimator only if it is not rejected as being better then OLS on the basis of a hypothesis test. However, as suggested by Mittelhammer et al., such a pretest estimator has lower risk than OLS only over a finite portion of the parameter space that depends, among other things, on the true parameter values and the significance level of the test (Judge and Bock; Judge, Bock, Yancy; Wallace). Furthermore, Sclove, Morris, and Radhakrishnan have shown that the traditional pretest estimator is inadmissible; that is, another estimator exists that has risk at least as small regardless of the true parameter values. Perhaps even more disheartening is that the sampling distribution of the pretest estimators is unknown, thus preventing usual tests of hypotheses and confidence interval statements.

While there is little positive that can be said about the hypothesis-testing dilemma, additional progress can be made with respect to obtaining point estimates that are superior to OLS under a general risk function of the form,

$$R(\hat{\beta},\beta) = \frac{E(\hat{\beta} - \beta)'Q(\hat{\beta} - \beta)}{\sigma^2}, \tag{1}$$

where $\hat{\beta}$ is an estimator of the parameter vector β, σ^2 is the error term variance defined below, and Q is a positive definite and symmetric matrix. Two common choices of Q are an identity matrix, yielding the weak mean square error criterion, and $Q = X'X$, yielding the mean square error of prediction criterion.

Let the linear model of concern be

$$\mathbf{y} = X\beta + \mathbf{e}, \tag{2}$$

where $\mathbf{y}$ is a $(T \times 1)$ vector of endogenous variable values, X is a $(T \times k)$ matrix of regressor values, β is a $(k \times 1)$ parameter vector and $\mathbf{e}$ is a $(T \times 1)$ vector of error terms normally distributed with mean zero and common variance, σ^2. The OLS estimator of β is $\mathbf{b} = (X'X)^{-1}X'\mathbf{y}$ which is indepen-

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[1] Principal components regression can be shown to be equivalent to a restricted least squares estimator (Fomby and Hill).

dent of $s = \mathbf{y}'M\mathbf{y} \sim \sigma^2\chi^2_{(T-k)}$, where $M = I - X(X'X)^{-1}X'$. Let the linear equations $R\beta = \mathbf{r}$ define J linearly independent, exact restrictions on β. The RLS estimator for β can then be written:

$$(3)\quad \mathbf{b}^* = \mathbf{b} + (X'X)^{-1}R'[R(X'X)^{-1}R']^{-1}(\mathbf{r} - R\mathbf{b}),$$

while the general Stein-like estimator can be written

$$(4)\quad \delta(\mathbf{b}, s) = \left[1 - \frac{as}{(\mathbf{r} - R\mathbf{b})'[R(X'X)^{-1}R']^{-1}(\mathbf{r} - R\mathbf{b})}\right] \times (\mathbf{b} - \mathbf{b}^*) - \mathbf{b}^*,$$

which is minimax and dominates the OLS estimator[2] if $k \geq 3$ and

$$(5)\quad 0 \leq a \leq 2\left(\lambda_k \sum_{i=1}^{k} \frac{1}{\lambda_i} - 2\right)\Big/(T - k + 2),$$

if $Q = I$ and

$$(6)\quad 0 \leq a \leq 2(k - 2)/(T - k + 2),$$

if $Q = X'X$. Here λ_i is the ith largest characteristic root of $X'X$, λ_k being the smallest. Note that if $Q = X'X$, or that the mean square error of prediction loss function is chosen, the value of the shrinkage factor, a, is not affected by λ_k or the degree of multicollinearity. The estimator described in (4) is in turn dominated by its positive-part variant

$$(7)\quad \delta^+(\mathbf{b}, s) = \left[1 - \frac{as}{(\mathbf{r} - R\mathbf{b})'[R(X'X)^{-1}R']^{-1}(\mathbf{r} - R\mathbf{b})}\right] I_{[a,\infty)}\left[\frac{(\mathbf{r} - R\mathbf{b})'[R(X'X)^{-1}R']^{-1}(\mathbf{r} - R\mathbf{b})}{s}\right] \times (\mathbf{b} - \mathbf{b}^*) + \mathbf{b}^*,$$

where $I_{[\cdot)}(c)$ is an indicator function that is equal to one if c falls within the stated interval, $[\cdot)$, but zero otherwise. Note that $(\mathbf{r} - R\mathbf{b})'[R(X'X)^{-1}R']^{-1}(\mathbf{r} - R\mathbf{b})/s$ is equal to $J \cdot F_{(J,T-k)}/(T - k)$, where $F_{(J,T-k)}$ is the F-statistic as reported by Mittelhammer et al. If $Q = X'X$ is chosen, then $a = (k - 2)/(T - k + 2) = .286$ for the Mittelhammer et al. models. The positive-part Stein-like estimator described in (7) that combines their reported OLS and principal components estimates can then be written,

$$(8)\quad \delta^+(\mathbf{b}, s) = \left[1 - \frac{.286}{.401}\right](\mathbf{b} - \mathbf{b}^*) - \mathbf{b}^*.$$

Results of applying the rule described in (8) along with the OLS and RLS (principal components regression) results of Mittelhammer et al. are presented in table 1.[3] As is apparent from table 1, the Stein-rule estimator shrinks the OLS estimates toward the prior information, the principal components estimates in this case.

The Stein-like estimators described in (4) and (7) provide point estimates that are superior to least squares under common loss functions regardless of the true parameter values and thus regardless of whether the exact restrictions are true or not. Unlike the traditional pretest estimator, these estimators do not choose between the OLS and RLS estimates, but rather, loosely speaking, average these estimates depending on the value of the appropriate F-statistic. The larger the value of F, holding T and k constant, the less weight is given the RLS estimator. Major limitations of the Stein-like estimators are that they are nonlinear and have unknown sampling distributions, just like the pretest estimators. Furthermore, like the pretest estimators, the covariance matrix of a Stein-like estimator can be derived, but is quite complicated and dependent on the unknown parameter vector—thus is of little practical use. Despite these limitations however, the Stein-rules presented above provide a way to combine sample and nonsample information in a way that guarantees risk improvement over OLS.

Conclusions

In this note, two estimators are presented that provide point estimates superior to OLS. With regard to mitigating the effects of multicollinearity, these estimators provide more precise parameter estimates than least squares in the sense of having lower risk. More important, unlike conventional pretest procedures, these risk gains are guaranteed. It is still true, however, that the better the prior

Table 1. Production Function Results for Using Alternative Estimation Techniques

	Coefficients		
Variable	OLS	RLS	Stein-like
ln$A$	−4.5108	−.0045	−1.2978
ln$L$	.4937	.3436	.3867
ln$N$	3.2300	.4808	1.2698
ln$K$	.1668	.2017	.1917
t	−.0553	.0111	−.0080
D_1t	−.0036	0.0000	−.0010
D_2t	−.0022	0.0000	−.0006
D_3t	.0018	0.0000	.0003

Note: OLS and RLS are the results reported in Mittelhammer et al. for "Model 1" and "Model 5," respectively (p. 202).

[2] See Strawderman for a discussion of a generalized ridge-type estimator which also dominates least squares.

[3] For the results reported in "Model 2" (Mittelhammer et al., p. 202), the argument for the indicator function in equation (7) lies outside the interval $[a,\infty)$ for $Q = X'X$. Therefore the positive-part Stein-rule estimates are equivalent to the RLS estimates reported by the authors.

information, i.e., the exact restrictions, the greater the gain that is realized over least squares.[4]

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Mitigating the Effects of Multicollinearity Using Exact and Stochastic Restrictions: The Case of an Aggregate Agricultural Production Function in Thailand: Reply

Ron C. Mittelhammer and Douglas L. Young

We thank Hill, Ziemer, and White (HZW) for their interest in our problem of mitigating the effects of severe multicollinearity and for their suggestion of a Stein-like estimator as an alternative estimator to those we examined. While the estimators HZW suggest can have attractive statistical properties under rather general conditions, we are less willing than they to discard the more conventional estimators, both for our specific problem and for many general applications. We will endeavor to support our reservations with technical arguments as well as on philosophical grounds.

We begin by noting that HZW have incorrectly stated the interval for the shrinkage factor 'a' in their Stein-like estimators (4) and (7) over which the estimator is known to dominate the OLS estimator [see their (5) and (6)]. It can be shown[1] that when using the risk function,

$$(1) \qquad R(\hat{\beta},\beta) = \frac{E(\hat{\beta} - \beta)'Q(\hat{\beta} - \beta)}{\sigma^2}.$$

The Stein-like estimators of Hill et al. are minimax and dominate the OLS estimator if

$$(2) \quad 0 \leq a \leq 2\left[\frac{tr(R(X'X)^{-1}R')^{-1}\, R(X'X)^{-2}R'}{\zeta_l} - 2\right] \Big/ (T - K + 2),$$

for $Q = I$, and

$$(3) \qquad 0 \leq a \leq 2(J - 2)/(T - K + 2),$$

for $Q = X'X$, where ζ_l is the largest characteristic root of $[R(X'X)^{-1}R']^{-1}\, R(X'X)^{-2}R'$, J is the number of independent linear constraints on the parameters of the linear model, and other notation is consistent with that used in HZW. It is recognized from (2) or (3) that there will exist a nonzero choice of 'a' only when the researcher has utilized a restricted least squares estimator in defining the Stein-like estimator that incorporates three or more independent constraints on the parameters, i.e., $J \geq 3$. Thus, for example, if a researcher were utilizing principal components regression in which only two components were deleted, corresponding to two constraints on the parameters of the linear model, the use of the Stein-like estimator of HZW to shrink the OLS estimator towards the principal components estimator would not be desirable under squared error risk ($Q = I$) or predictive risk ($Q = X'X$). In the special case where $J = K$, so that the restricted least squares estimator, b^*, used in the Stein-like estimator is defined as the nonstochastic $K \times 1$ vector $\mathbf{R}^{-1}r$, the Hill, Ziemer, and White bounds are correct. Of course, in the context of usual applications of principal components regression where the dependent variable is regressed on principal components as explanatory variables, components are deleted, and then estimates of parameters in the original coordinate space are generated, the special case where $J = K$ is of virtually no interest, because this is tantamount to restricting all parameters in the original coordinate space to zero. Thus, the applied researcher should be aware of the general bounds (2) and (3) should he or she be interested in applying one of the Stein-like estimators suggested by HZW to a given estimation problem.

At this point, it becomes interesting to ascertain whether the Stein-like estimators suggested by HZW can be defined so as to dominate the OLS estimator and provide improved parameter estimates. We should note that one of our original problem objectives was to obtain precise estimates of the parameters of the agricultural production function we had specified. And, to be sure, the squared error risk function, i.e., (1) with $Q = I$, is useful in gauging estimation performance in the parameter space. Because in our case $J = 6 \geq 3$, calculation of the estimator could be useful. Unfortunately, our case is an example where the Stein-like estimator is not unambiguously superior to the OLS estimator, for when the interval for 'a' suggested by (2) is calculated, we find the calculated upper bound for 'a' to be $-.0935$. Thus, the Stein-like estimators suggested by HZW do not possess the property of dominating the OLS estimators in our case, and thus, their principal virtue is not realized. It should be noted that the failure of the Stein-like estimator in our case was due to a mul-

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[1] The proof of this result, as well as others included in this paper, are omitted due to space limitations. The proofs are essentially variations on proofs contained in Judge and Bock in their discussion of Stein-like estimators. Interested readers may obtain these proofs upon request from Ron Mittelhammer.

ticollinearity structure in the matrix $[R(X'X)^{-1}R']^{-1} R(X'X)^{-2}R'$ that resulted in ζ_l being quite large relative to the remaining smaller characteristic roots. Whether this failure occurs in general depends on the structure on the multicollinearity in any given problem. The failure is less likely to occur when $[R(X'X)^{-1} R(X'X)^{-2}R'$ has two or more large characteristic roots of roughly similar magnitude.

Although the estimators suggested by HZW were not useful for improving the estimates of the parameters of the production function themselves, as judged by the squared-error risk criterion, they are superior to the OLS estimator if judged by the predictive risk criterion, i.e., (1) with $Q = X'X$, as HZW contend. That is, in our problem with $J = 6$, there do exist choices of the shrinkage factor 'a' that, when used in the Stein-like estimators suggested by HZW, produce an estimator which dominates the OLS estimator and is minimax under the predictive risk measure. Because an objective of our original problem was to obtain precise predictions of agricultural output, consideration of predictive performance was relevant.

We should point out that using the midpoint of the interval for 'a'—recall (3)—in our case where $J = 6$, $T = 27$, and $K = 8$, results in a choice of the shrinkage factor equal to .190, and not .286, as utilized by HZW. The choice of the midpoint of the interval has special significance when the general Stein-like estimator is used—see HZW, equation (4), for it represents the choice of the shrinkage factor that results in the Stein-like estimator with smallest predictive risk, regardless of the degree of error in the restrictions imposed. However, unlike the general Stein-like estimator, the positive-part estimator—see HZW, equation (7)—is such that there does not exist a choice of 'a' in the interval (3), which is optimal from the predictive risk standpoint, because the risk functions of the positive part estimators can cross for various choices of 'a'. Nonetheless, it is known that the positive part estimator dominates the general Stein-like estimator in predictive risk for corresponding choices of 'a'. Using the midpoint value of 'a' = .190, we calculate the general Stein-like or positive part estimates (they are numerically identical in this case) for our production function to be

$$(4)\quad y = .0930\, L^{.4225}\, N^{1.9274}\, K^{.1833} \exp\{-.0238_t - .0020D_1t - .0012D_2t + .0009D_3t\},$$

which are in contrast to the estimates presented by HZW.[2]

Now that the Stein-like estimates of the parameters, which dominate OLS estimates in predictive risk, have been defined, the question is whether they should be utilized for prediction or the restricted least squares estimates should be used.[3] What are the most important benefits and costs of using the Stein-like estimator as opposed to using the restricted least squares estimator? The obvious advantage of the Stein-like estimator is that it is known to dominate the OLS estimator in predictive risk regardless of the validity of the constraints—how much better the Stein-like estimator is relative to the OLS estimator of course depends on how close the constraints are to being true (as measured by the size of the noncentrality parameter associated with the F-test of constraint validity). However, there is a potential cost to be paid for obtaining this guaranteed dominance. The Stein-like estimators do not dominate the restricted least squares estimator in predictive risk (nor in squared error risk). There is a subset of the parameter space where the constraints are nearly correct (small noncentrality parameter) and where the restricted least squares estimator can beat the Stein rule estimators in risk measure quite handily. For example, in a case such as ours with $J = 6$, $T = 27$, and $K = 8$, if the constraints imposed were actually correct, the general Stein-like estimator would have over twice the risk of the restricted least squares estimator.[4] A graphical illustration of these relationships is presented in figure 1 comparing OLS, restricted least squares (RLS), and the general Stein-like estimator when the shrinkage factor in the Stein-like estimator is chosen to be $(J - 2)/(T - K + 2)$, the midpoint of the interval in (3).

In application, the researcher never will know with certainty whether the restricted least squares or Stein-like estimator is superior with respect to predictive risk (or squared error risk). If the researcher is completely ignorant of the validity of his constraints, we must agree with HZW that Stein-like estimators, when they provide minimax alternatives to OLS, are attractive in terms of risk properties. In our case, although we feel there is a priori evidence to support zero restrictions on the dummy variables representing differential technological progress over government planning periods, we have little basis for presuming the validity of the zero restrictions on linear combinations of the parameters imposed by the deletion of three principal components. Faced with this ignorance, one might have suspected that we would find the suggestion of

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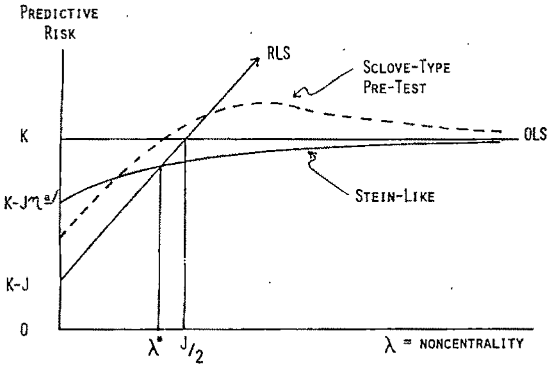
[2] We note in passing that neither the Stein-like parameter estimates computed by HZW nor those reported in (4) appear to be theoretically plausible. Both labor elasticity estimates indicate well in excess of a 1% increase in output for a 1% increase in labor input, which strikes us as exhorbitant for the relatively aborabundant, low-wage Thai agricultural economy. The returns to scale estimates, 1.8482 in HZW and 2.5332 in (4), also greatly exceed theoretical expectations and empirical estimates generally found in the aggregate production function literature. Both Stein-like technology coefficient estimates are negative, implying technological decay in Thai agriculture between 1950 and 1976

[3] Following the terminology of HZW, when we refer in this reply to the restricted least squares estimator of the aggregate agricultural production function in our previous work, we are referring to the restricted least squares estimator represented by our principal components regression estimator (model 5 in table 2, Mittelhammer et al., p. 202).

[4] The actual predictive risk for the restricted least squares estimator is 2, and for the general Stein-like estimator, 4.381, in a case such as the one described, with the noncentrality parameter being zero (the constraints are correct).



[a] $\eta = \dfrac{(J-2)(T-K)}{J(T-K+2)}$, λ^* is that value of λ such that

$$\lambda = J/2 - E(1/\chi^2_{J,\lambda})\frac{(J-2)^2(T-K)}{2(T-K+2)}.$$

Figure 1. General predictive risk comparisons between OLS, RLS, optimal general Stein-like, and Sclove-type pretest estimators

the Stein-like estimators appealing. However, we were left with an uneasy feeling that we might be foregoing an opportunity for lowering predictive risk by choosing the Stein-like estimator as opposed to the restricted least squares estimator in this case. For example, with reference to figure 1, we find that in our problem the general Stein-like estimator's risk function crosses the risk function of the restricted least squares estimator when the noncentrality parameter equals $2.64 = \lambda^*$. The calculated F-value corresponding to the six restrictions imposed on the parameters of our production function specification was 1.27 (see Mittelhammer et al., p. 202, table 2). With reference to the noncentral F density with 6 and 19 degrees of freedom, and noncentrality parameter $\lambda = 2.64$, we find that $P[F_{6,19}; \lambda = 2.64 \geq 1.27] = .703$. Thus, there is very strong sample evidence supporting the hypothesis that $\lambda \leq 2.64$ and that the restricted least squares estimator is superior to the general Stein-like estimator in predictive risk. However, it is admittedly sample evidence of superiority and not an unequivocal guarantee. Furthermore, if we were to base our choice of estimator on a noncentral F-test of predictive risk superiority, a pretest estimator would be defined of the Sclove, Morris, Radhakrishvan form (see Judge and Bock, p. 189). An illustrative graph of a typical predictive risk function for the Sclove-type pretest estimator is included in figure 1. The pretest estimator would choose the restricted least squares estimator in our case for all critical levels of the risk superiority test associated with probabilities of type I error $\leq .703$. While the pretest estimator has the advantage of a bounded risk function (the restricted least squares estimator has unbounded risk), it is seen in figure 1 that the potential for gains over the Stein-like estimator is eroded. The exact position of the risk function depends on the choice of critical point for the superiority test where, roughly speaking, higher critical values pull the risk function of the pretest estimator towards the restricted least squares risk function (see Judge and Bock, chap. 3).

In light of the preceding discussion, it might appear prudent to accept the Stein-like estimates (4) as formidable competitors to the restricted least squares estimates for prediction purposes. In the absence of any further information on the location of the noncentrality parameter, the researcher might be wise to choose conservative estimates generated by the Stein-like estimators suggested by HZW. However, two final observations on the behavior of the Stein-like estimator motivate us to discard the Stein-like estimates and retain our restricted least squares estimates for use in deriving policy conclusions in our original research. First, we were alerted to the necessity of subjecting the Stein-like estimator to further scrutiny by the blatantly unrealistic decomposition of agricultural growth between conventional inputs and technological advance implied by the Stein-like estimates. Specifically, with reference to our original table 4 (Mittelhammer et al., p. 208), the conventional input share of increased agricultural output using the Stein-like estimates is calculated to be 238.4%, while the share due to technological progress equals −138.4%. Searching out an explanation for these rather startling results derived from estimates with supposedly attractive predictive risk properties, we found an answer in the definition of the predictive risk function itself. The Stein-like estimator is known to dominate the OLS estimator in predictive risk measure, where the predictive risk measure (1) with $Q = X'X$ is measuring expected squared distance between $\hat{\beta}$ and β in the $X'X$ metric, or equivalently, expected squared Euclidean distance between the vectors $\hat{y}$ and $E(y|X)$. As such, the predictive risk measure is relevant to predictions made conditional on the historically observed X matrix. The measure is a useful one and was of direct relevance in our case since output predictions for years included in the data set were required for the decomposition of agricultural growth. However, the decomposition calculation also required a prediction using 1976 levels of conventional inputs together with 1950 levels of the technology proxy variables, a set of values for the explanatory variables which was not in the data set X and is a situation quite removed from historical precedent.

We defined a risk measure of the form (1), where $Q = X_*'X_*$ and X_* was the $(n+1) \times K$ matrix comprised of the original X matrix with an additional row representing the appropriate explanatory variable values for this historically unprecedented situation. Thus, the new predictive risk function also measures the performance of the prediction of the expected value of agricultural production conditional on 1976 levels of conventional inputs and a 1950 level of the technology proxy. The bounds for the shrinkage factor utilized in the Stein-like estimator in this special case can be shown to equal

(5) $0 \leq a \leq 2\left[\frac{J - 2 + \eta}{1 + \eta} - 2\right] \Big/ (T - K + 2)$,

where $\eta = x_{n+1}\ S^{-1}R'(RS^{-1}R')^{-1}\ RS^{-1}\ X'_{n+1}$ and X_{n+1} is the row of explanatory variable values added to the X-matrix. The calculated upper bound in our problem was found to equal $-.0944$, and thus the Stein-like estimator is not useful for the prediction purposes of our study.

In concluding, we contend that the researcher plagued by severe multicollinearity is unlikely to find comfort by mechanically appealing to a single estimator whose principal virtue is dominance over OLS in some sense, be it the Stein-like estimator or some competitor. We believe our arguments above underscore the need to exercise sound case-by-case judgment in selecting estimators. Such judgment should include the definition of risk functions appropriate to the intended application of the results. It should also include an honest assessment of the reliability of any imposed constraints.

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An Economic Evaluation of Alternative Peanut Policies: Delayed Reply

W. L. Nieuwoudt

In his "Comment," Trapp concludes that the year 1973 on which the peanut model of Nieuwoudt, Bullock, and Mathia (1976b) is based (hereafter called NBM) is atypical for the peanut market because high oilseed prices (soybeans and cotton) during 1973/74 shifted the peanut demand to the right for that year. More specifically, he concludes that where the NBM model predicts an increase in peanut production and gross revenue if the peanut program were abolished, the opposite will happen under more typical conditions. As evidence, he showed that production costs of peanuts exceeded estimated open market prices during 1970–76 except for 1973/74. Trapp's comment raises several questions which will be examined. It will be shown that his theoretical argument ignores a supply shift, and that his cost data include substantial rents.

Interrelationship between Supply and Demand Shifts

The main shifters in Trapp's peanut demand models are soybean and cottonseed prices. According to soil maps and opinions of peanut experts, about 1.4 million acres currently under soybeans (Southeast) and about .6 million acres under cotton (Southeast and Southwest) are suitable for peanut production (Nieuwoudt et al. 1976a). Peanuts and soybeans have similar agronomic characteristics; for example, rotation with other crops such as corn (Southeast) is recommended by the Extension Service in the interest of weed control. Fleming and White (1975) estimated regional supply functions for peanuts showing that gross income from soybeans and cotton are important shifters of peanut supply. A depressed oilseed market is thus expected not only to shift the peanut demand to the left, as illustrated by Trapp (figure 2), but should shift the peanut supply to the right. Theoretically the supply shift could be greater, smaller, or equal to the demand shift. A supply shift which offsets the demand shift would keep the ordering of *Pm*, *Pe*, and *Po* unchanged (Trapp, p. 109) leaving the conclusions drawn in the NBM study unaltered. Trapp's theoretical discussion creates a one-sided view by only focusing on a demand shift while ignoring a possible corresponding supply shift.

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Trapp quotes cost and marketing data to support his theoretical analysis. The data he used will be examined in relation to the NMB study.

Opportunity Cost of Peanuts

Trapp included land charges in his costs of production (U.S. Department of Agriculture ESCS budgets) to allow for opportunity income of other crops. The question is whether the data that he used, correctly reflect opportunity income of peanut production. According to him, his land charges figures "are largely exclusive of the effects of peanut allotment rentals upon land price since peanut acreage constitutes a small percentage of the land used in these areas." Evidence will be shown that contradicts this statement implying that peanut allotment rentals are a significant component of peanut cost of production quoted by Trapp. According to the USDA report (USDA ESCS *Report*, 15 June 1979), "cropland values for 1977 by crop-reporting districts were weighted by crop acreages in these districts to arrive at a separate land value for each crop for each State" (p. 3). Peanuts are grown in the United States in certain well-defined localities. In these specific areas, peanuts are one of the most important crops. Calculating land rents (land costs) using such a weighting procedure implies that the land cost figure determined for peanuts would include peanut allotment rents to an important extent. The USDA-ESCS report states further that composite land costs "include the value of land as well as the value placed on the peanut allotment" (p. 34), and that cost as measured for individual commodities is a derived total. In this context, income per acre equals costs per acre because all rents are accounted for (Euler theorem). A fall in oilseed prices as Trapp describes would have tended to increase peanut allotment rents as reflected in peanut budgets because of past peanut support prices, while opportunity costs of growing peanuts would have fallen. The sum total of land and allotment rents would not have changed.

To gain an impression of these opportunity costs, land costs for the main crops grown in peanut areas as reported in USDA-ESCS budgets are summarized in table 1. The data are revealing. Land cost figures included in USDA-ESCS peanut budgets are substantially higher than land cost included in budgets for substitute crops in the same

areas. For example, while land costs per acre in budgets for the main peanut substitutes in the Southeast for 1978 varied from $43 to $49, cost of land in peanut budgets were, respectively, $140 and $121 for the Georgia and North Carolina areas. This confirms the above conclusion that peanut land costs in peanut budgets (USDA-ESCS budgets, 1974–79) include substantial allotment rents. A better estimate of the opportunity costs of peanuts, for example in the Southeast, would be land costs (rents) of soybeans, corn, and to a lesser extent cotton and wheat.

If open market prices of peanuts exceed peanut costs in a given area, then if allotments are terminated, some allotment rents will be captured as land rents, and rent of peanut land (excluding allotment) should increase above current opportunity costs. This situation is depicted in Nieuwoudt's and Bullock's studies for all peanut areas except the nonirrigated peanuts in Texas. If Trapp's alternative conclusions are valid, however, then peanut land rents would fall to below current opportunity costs (Bullock, case 2). To investigate whether free market prices exceed peanut costs as Trapp has done, it thus appears reasonable to estimate peanut opportunity costs by prevailing rents of land of substitute crops as in table 1.

Allotment Transfers

Trapp (p. 108) states that in the NBM model, constant marginal cost of production is assumed while in actuality, the market for peanut allotments is less than perfectly competitive because peanut allotments can be transferred only within county borders. On the contrary, because data for fifty-nine resource areas were built into the NBM model, the phenomenon that peanut transfers are only permitted within county borders was one of the important checks on the validity of the NBM model (table 4), because allotment rents for counties could be compared with shadow prices on the model allotment constraints. The marginal cost curve for peanut production generated within the NBM model is positive sloping because individual resource areas included in this model have different comparative advantages, as is evident from differences in allotment rents. The long-run equilibrium price (free market) is only equal to the local average cost of production in a given county as generated within the model in the sense that the portion of peanut allotment rent transferred to land for the given county, in the form of a shadow price on land, is included in cost of production.

Trapp compared national cost data, determined as a weighted average of costs of production in current production areas, with open market peanut prices. In a free market, production would flow to lower cost areas, and production costs would fall. This phenomenon was incorporated in the NBM model. National cost data may overstate free market costs of production to a significant extent. Using cash rent data published in the USDA-ESCS reports and opportunity costs as measured in table 1, it is estimated that peanut prices (1977) need to fall by 5.4 cents per pound before peanuts would disappear from Georgia while in Texas it needs to fall .5 cents per pound. The NBM study estimated that peanut prices (1973) need to fall by 6.2 cents in Georgia, 1.30 cents in Texas dryland, and 3.9 cents for Texas irrigation before peanut production would disappear, which shows important differences in regional cost (opportunity cost inclusive).

Fall in Gross Revenue

Trapp concludes that where the NBM study showed an increase in gross revenue received from peanut sales, under more typical conditions it would decline. His argument creates the impression that producers according to the NBM model would be better off under a free market situation, while his study points to the opposite. This is not the case, as the NBM study estimates on pp. 490 and 492 (table 7) that producer surplus of all crops under free

Table 1. Costs Allocated to Land of Crops Grown in Peanut Areas

	Southeast ($ per acre)						Southwest ($ per acre)		Opportunity Cost (¢/lb.)	
	Peanuts									
Year	NC/VA	Georgia, Alabama	Soybeans	Corn	Cotton	Wheat	Peanuts	Grain Sorghum	Southeast	Southwest
1979			49.4	52.5	45.5	46.7		30.5	1.65	1.76
1978	121.2	140.2	46.2	49.1	42.6	43.7	43.3	28.6	1.56	1.82
1977	113.9	122.5	43.0	44.1	35.6	38.9	48.3	26.7	1.53	1.73
1976	100.3	83.5	41.3	45.8	41.3	41.6	39.4	25.5	1.58	1.56
1975	79.7	88.6	38.3	41.1	38.3	43.2	40.4	30.9	1.37	1.91
1974	93.8	70.4	36.9	41.3	36.6	NA	NA	30.8	1.37	1.96

Note: Based on estimated current value of cropland multiplied by current interest rates on Federal Land Bank mortgage loans. Data not available for 1970–1973. All data obtained from USDA ESCS budgets for subsequent years.

market conditions would be lower than under the current program.

If dollar sales from peanuts are actually lower under a free market situation, as Trapp concludes, then producer surplus also would be lower, which is in accordance with the NBM study although the magnitude of change would have been more. This clearly does not contradict the findings of the NBM study seen in the spirit in which policy objectives were evaluated. The NBM study states on p. 489, "No claim for the precision of these estimates is made. However, the consistent estimation procedures used across policy alternatives should provide a good measure of the relative impact each alternative has in the various dimensions."

Peanut sales and producer surplus for peanuts only were numbers reported in a table in the NBM study (p. 490), but it was never mentioned in the text as it was considered unimportant in relation to the theme of the paper. The objective of the paper was the evaluation of policies using criteria such as producer surplus (all crops), treasury loss, social costs, etc. The reason producer surplus of all crops fell in the NBM study while peanut sales expanded in the free market alternative is attributed to the loss in producer surplus of products displaced as captured in a programming model. If export prices exceed peanut costs (opportunity cost inclusive), peanut sales may in fact be more under a free market situation. This hypothesis cannot be tested using time-series data because time-series peanut supply functions cannot be estimated.

While a fall in peanut sales would still fall within the spectrum of conclusions arrived at in the NBM study, a reduction in peanut acreage (Trapp's other point) would seriously contradict estimates of the NBM study. The latter point will be further examined.

Free Market Prices for Peanuts

Trapp estimated "open" market prices for U.S. peanuts from local demand functions for edible and crushing peanuts as reported by Song; Song, Franzmann, Mead; Fleming and White (1975, 1976). The Song model is based on the period 1952–1972 and the Fleming model on the period 1960–1973. These models ignored the export market. Exports increased significantly during 1970–1979 and exceeded crushings for oil since about 1973, except for 1975 and 1976 when "toll" crushing occurred. The dramatic increase in peanut export prices during 1970–79 could also not be foreseen by the Song and Fleming models. Export prices of U.S. Runner peanuts increased threefold from 1970 to 1979.

There is also a mathematical problem in the way the Song and Fleming models were employed because Trapp's open market prices are below crushing prices. If the open market price is derived from crushing and edible demand functions, then the open market price determined in such a way must lie between the actual crushing and edible peanut prices of corresponding years if available supplies on the local market for those years are taken as given. Trapp reported "estimates of open market clearing prices for actual peanut production levels . . . ."

Only the larger peanut kernels are suitable for export as edible peanuts, and it does appear reasonable that the net export price would have been close to the crushing price and slightly better during the period, because if the crushing price is higher more peanuts would be crushed. The U.S. share in the world peanut market is about 18% (Fleming and White 1976), and world peanut prices should be a good indication of U.S. free market prices. It can thus be concluded that U.S. free market prices for the period 1970–1979 would have been close to actual crushing prices. Trapp's estimates of free market prices were generally well below actual crushing prices; for example, the actual crushing price in 1973 was 12¢ per pound, but the free market price was estimated at 9.88¢ per pound.

To test Trapp's statement that free market peanut production would decline, new data need to be presented on export prices and costs, which fall outside the scope of this Reply. According to The Overseas Farmers Co-operative (London), export prices of U.S. Runner peanuts increased from 9.1¢ per pound in 1970 to 27.1¢ per pound in 1979. If USDA ESCS cost data are adjusted using opportunity cost data as presented in table 1, it appears possible that U.S. peanut production may have expanded under free market conditions for most of the years during the period 1970–79, contrary to Trapp's conclusion.

The main criticisms of Trapp's study are that although he used official USDA budgets, allotment rents are reflected in peanut costs while the export market was also ignored, although exports exceeded crushing since 1973 except for 1975 and 1976 when "toll" crushing occurred.

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The Agricultural-Food Policy Agenda for the 1980s
(Robert G. F. Spitze, University of Illinois, Presiding)

Reconciling Agricultural Pricing, Environmental, Conservation, Energy, and Structural Concerns

Marshall A. Martin

After two decades of relatively stable prices, stagnant export growth, and relatively cheap energy, U.S. agriculture underwent a series of dramatic changes in the 1970s. Commodity prices rose sharply in the mid-1970s in response to shortfalls in world grain production, devaluation of the dollar, and increased exports to the USSR. Actions in October 1973 and since by the Organization of Petroleum Exporting Countries (OPEC) resulted in sharp increases in the price of petroleum. Prices of agricultural inputs derived from petroleum such as nitrogen fertilizer and pesticides also have risen.

These and other economic forces (e.g., technological change, tax policies, and inflation) have encouraged established farmers to expand the size of their operations to take advantage of scale economies and to increase farm income. Other farmers, especially middle size operations and beginning farmers, have been confronted with sharply higher capital requirements as land values and other input costs have risen faster than commodity prices. Consequently, the structure of agriculture has continued to change, with fewer farmers producing an increasing share of total output (*Economic Report of the President,* pp. 309–12; see also Martin and Spitze).

Throughout the post-World War II era, cropland has been used more intensively with dramatic increases in land productivity. Rapid expansion in the application of fertilizer and agricultural chemicals has made a major contribution to the increase in land productivity (*Economic Report of the President,* pp. 309–12). However, some of these chemicals have been found to be harmful to the environment and/or human health. And there are doubts about some still in use. In some cases their use has been banned or restricted. Also in recent years, as land has been used more intensively and as marginal land has been brought into production, there have been increasing problems with soil erosion and sedimentation in the nation's waterways.

High petroleum prices and increased U.S. dependence on foreign sources has stimulated interest in the use of grain and biomass for the production of ethanol as an alternative source of fluid energy. Expected growth in ethanol production will place additional strains on the nation's resource base, especially cropland.

As a result of these changing economic conditions, the principal food and agricultural policy issues of the 1980s are likely to be:

(*a*) How can we reduce price and income variability in a growing and more interdependent world market?

(*b*) To what extent will government protect returns to land and other fixed resources?

(*c*) How can we reconcile the private and social costs and benefits of conservation and environmental concerns?

(*d*) To what extent will agricultural output be devoted to ethanol production?

(*e*) What level of financial support will be given to agricultural research?

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(*f*) How will public policy be used to shape the structure of agriculture?

This article provides an interpretive summary of these policy issues and tries to reconcile the interplay and conflicts among them.[1] The primary focus of the discussion is on the implications for future land policy.

Price and Income Policies

Despite recent growth in foreign demand which tends to be price elastic for a particular country such as the United States, the short-run demand for U.S. farm products is still price inelastic. Greater dependence on foreign markets can contribute to increased domestic price and income variability. U.S. export demand can vary due to changes in world agricultural production, changes in exchange rates, or decisions made by marketing boards or authorities in centrally planned economies (Spitze and Martin; Schuh; Robinson).

Wide swings in product prices not only result in fluctuations in farm income, but also give erroneous production and consumption signals. Farmers have greater difficulty formulating optimal production decisions. This results in inefficient resource allocation. Price uncertainty also affects consumer behavior and can lead to consumer unrest, especially in periods of sharply rising prices.

In a market economy, changing relative prices are necessary to allocate production and influence consumption. The question is: How much price and income stability is economically, socially, and politically desirable?

Several price and income policy innovations were adopted in the 1970s. The Agriculture and Consumer Protection Act of 1973 introduced a two-tiered government price and income support system. Target prices have been used to provide some income protection by means of deficiency and disaster payments. Loan rates provide a price floor. They are used to determine the value of nonrecourse loans for eligible farmers and are utilized in operational rules for release of grain from the farmer-owned grain reserve.

Although the target price levels have been adjusted twice by Congress since the passage of the Food and Agriculture Act of 1977, the basic legislative intent is to adjust target prices based on changes in per unit costs of production. The 1977 Act also replaced the historical farm acreage allotments with a voluntary set-aside procedure based on current plantings.

Another major policy innovation in the 1977 Act was the concept of a farmer-owned grain reserve. The primary objectives of the grain reserve are to help stabilize commodity prices and to help insure adequate supplies for export sales and food aid. Eligible farmers, after receiving a nonrecourse loan, may elect to store their grain for up to three years and receive a prepaid storage payment and some interest and farm storage loan concessions. Farmers retain ownership of the grain and make the final marketing decisions but can be influenced by penalties. The grain reserve program provides farmers with incentives to store in periods of low prices for later sale when prices rise. A release and call price procedure based on percentages of the loan rate is used to encourage gradual release of the grain from the reserve back into normal market channels. (For a detailed discussion of farm commodity legislation in the 1970s, see Tweeten, Martin and Spitze.)

The demand for grain for export sales and for ethanol production is expected to expand in the 1980s. At the same time there are likely to be additional restrictions on the use of agricultural chemicals as well as efforts to encourage soil conservation measures resulting in a more modest growth in the supply of agricultural products. Consequently, commodity prices are likely to rise, thereby reducing the likelihood that set-aside measures will be imposed in the decade ahead.[2] Target prices and deficiency payments will become relatively less important as policy instruments.

The major price and income policy issue of the 1980s likely will focus on the level of the loan rates and the use of the grain reserve to stabilize prices. Loan rate levels will be de-

[1] In analyzing a framework for food and agricultural policy for the 1980s, Lee describes a similar set of emerging issues.

[2] Some preliminary estimates by Jerry A. Sharples, using FEEDSIM, suggest that a high rate of export demand growth—continuation of rates in the 1972–80 period—and low growth in productivity, 1.5 and 0.4 bushels per year growth in average corn and soybean yields, respectively, would result in substantially higher real corn and soybean prices in the 1980s. Both corn and soybean prices would increase at an annual rate of 13%. He assumed a 2% annual growth in corn demand. This could be higher depending on expected growth in ethanol production. About 20 million additional acres would be required for these two crops alone by the mid-1980s. Sharples estimated that even if yields increased at the rate experienced since 1960 (2.0 and 0.5 bushels per acre per year for corn and soybeans, respectively), growth in domestic demand at the same rate as in the 1970s, and export growth at half the actual rate of the 1972–80 period, real corn and soybean prices would increase at an annual rate of 4%–5% and about 4 million additional acres would need to be brought into corn and soybean production by the mid-1980s. See Holland and Meekhof for more detail on the FEEDSIM model.

termined largely by budget considerations, relationship to world market prices, changes in production costs, influence on the acquisition and release of grain in the farmer-owned reserve, and possible structural impacts.

The public's conception of the price and income problem also may change. Prior to the 1970s, the perceived problem was low and falling farm prices and income. The public was willing to provide some farm price and income support. During the 1980s, the public's main concern likely will be directed toward rising food prices for consumers and rising production costs for farmers. The legislative focus probably will be on means to stimulate production, enhance competitive pricing to help restrain inflation, and encourage export sales.

Environmental and Conservation Issues

Our present problems of environmental pollution result from more intensive use of our natural resources, particularly land and water. And a better educated, better informed, more affluent, and more mobile population has demanded improved standards of environmental quality. These pressures led to congressional approval in the 1970s of various new regulatory agencies and laws (see Paarlberg).

Sediment is the largest single pollutant of surface water. Soil erosion losses have been estimated as high as 4 billion tons a year, with one billion tons reaching the major rivers. About half of this erosion is from agricultural lands. Annual soil losses from cropland range from one to 100 tons per acre, depending on the crop system, management practices, rainfall, soil characteristics, and topographic features (Wischmeier).

Sediment is also an important carrier of plant nutrients, pesticide residues, and infectious agents. Plant nutrients from soils, animal wastes, and fertilizers have contributed to local problems of excess aquatic growth (eutrophication) and nitrate contamination of ground water supplies.

Approximately one million acres of prime farmland (0.3% of cropland currently in production) are converted each year to urban uses (Brubaker). Consequently, farmers will need to use more variable inputs, such as fertilizer and pesticides, and/or bring additional marginal land into production as they seek to expand agricultural output to meet the expected growth in export and domestic demand. This will exacerbate problems of soil erosion and sedimentation.

Only about 30% of the sediment load comes from cropland where changes in tillage systems can reduce sediment loss. The greater portion of the sediment load comes from noncropland, e.g., construction sites, grazing land, and waste land (Paarlberg).

Wade and Heady estimate that it would cost $13.4 billion annually to reduce the sediment load from cropland by 90%. However, such reduced tillage and conservation efforts on cropland would leave the noncropland unaffected. Consequently, the total sedimentation load would only be reduced by about 23%.

There is little economic incentive in the shortrun for an individual farmer to adopt those conservation practices that may reduce short-run production and increase costs, particularly if the land is farmed under a short-run rental or lease arrangement. Consequently, land tenure arrangements often do not fully reflect the externalities associated with current tillage practices. However, as land values and energy costs have risen in recent years, farmers have adopted tillage practices that reduce soil loss and energy use.

In order to internalize the externalities associated with nonpoint pollution, a joint effort among farmers and the government will be necessary. Some type of governmental incentives will be needed to encourage farmers to discontinue fall plowing of certain soils, use contour farming techniques, and take marginal land out of production. Farmers who follow recommended soil conservation practices could be guaranteed a conservation diversion payment or become eligible for certain farm commodity program benefits. (Benbrook provides an excellent summary of alternative ways to integrate farm commodity programs and soil conservation efforts. He also explores some of the institutional implications.)

Various researchers (Headley and Lewis; Taylor and Frohberg; Cashman, Martin, McCarl) have examined the economic impacts of restrictions on pesticide use. The short-run, farm-level and aggregate losses in production and income are generally small if the use of only one or two of the primary pesticides is prohibited. However, as the number of pesticides banned is increased, production losses increase substantially. In many cases farmers must turn to different crop rotation systems or higher-cost, less effective pest control practices. The irony of potential pesticide bans is

that, given the inelastic, short-run demand for most agricultural products, further restrictions on pesticide use could affect consumers more adversely than farmers.

Environmental and conservation issues are certain to be major policy concerns in the 1980s. Farmers and environmentalists often perceive great differences in their goals and points of view. A reduction in soil loss is in the long-term interest of farmers, consumers, and environmentalists. Alternative ways must be found to equate private and social costs and benefits. A combination of taxes and subsidies can be used to reduce soil erosion and agricultural pollution.

Integrated pest management, biological controls, and better cultural practices potentially can reduce pesticide use and production costs without major reductions in production. Future policy efforts to reduce soil erosion and agricultural pollution will require additional research knowledge on the interface between pesticide use, energy requirements, and soil losses.[3] Also, research efforts on the environmental impacts of continued growth in export and domestic demand for grains should be given high priority.

Energy Policy

Growing scarcity of global energy supplies will present a major challenge to U.S. agriculture in the decade ahead. Scarce liquid fuel supplies and rising prices could significantly alter resource use, cropping patterns, and the level of agricultural production. This could result in changes in relative commodity prices, farm income, food prices, and regional comparative advantage, especially if grains and biomass are used increasingly to produce ethanol.

Such a scenario raises a number of new policy questions. Some are related to conflicts between resource use for food versus fuel production. Others involve the environmental implications of increased use of land, water, and other scarce resources to meet growing food and fuel demands.

Currently, the food sector accounts for 16.5% of total U.S. energy consumption. Production agriculture directly and indirectly uses about 3% of total U.S. energy use. Thus, reductions in energy use in production agriculture will have only a minimal impact on the national energy problem.

About 93% of the energy used in production agriculture is derived from petroleum. Fertilizer composes about one-third of the energy used in agricultural production. Fuel for irrigation and natural gas for crop drying are two other major forms of liquid energy used in agricultural production (Paarlberg).

Various proposals have been made to reduce the amount of energy used in production agriculture, e.g., more crop rotation, less use of nitrogen fertilizer, and less reliance on artificial crop drying. While such practices have merit in certain circumstances, in many cases such approaches would result in lower yields and higher production costs per acre and per unit of output.[4]

The major energy challenge for U.S. agriculture in the 1980s will involve the production of ethanol from grain and agricultural byproducts. Production of ethanol is particularly attractive to grain farmers because it could increase the demand for grain and thereby increase their incomes.

Initially, a gasohol program was viewed by some people as a way to alleviate grain surpluses and eliminate the need to pay farmers to idle farm land. Increasingly, it is being viewed as a way of increasing farm income, generating employment, and reducing U.S. dependence on imported oil.

Feed grain and wheat set-aside and diversion acres totaled 16.7 million and 10.5 million acres in 1978 and 1979, respectively. This acreage could have produced about 972 million bushels of grain in 1978 and 550 million bushels in 1979. At a conversion rate of 2.6 gallons per bushel, this implies 2.5 and 1.4 billion gallons of ethanol in 1978 and 1979, respectively, or an average of 1.95 billion gallons per year. This represents about 2% of annual gasoline consumption in the U.S.

Meekhof, Tyner, and Holland have examined the economic implications of eliminating all set-aside and diversion programs and using a price guarantee for major grain crops. They assume that the government would buy the grain at or above the loan rate and subsidize its

[4] A rational energy policy in a market economy suggests that efforts to reduce energy use in agricultural production should reflect changes in relative prices and should not be based on an "energy theory of value" that only seeks to minimize the number

conversion into ethanol. The subsidy would make the wholesale price of gasohol roughly equivalent to unleaded gasoline.

Alternative levels of ethanol production were analyzed ranging from 1 to 4 billion gallons of ethanol (0.4 to 1.5 billion bushels of corn). Levels of 1 to 2 billion gallons had relatively little impact on corn and soybean prices, production, exports, and domestic disappearance. Levels of 3 to 4 billion gallons tended to increase corn prices substantially, reduce corn exports, reduce domestic disappearance, and increase price instability of both corn and soybeans. Increased supplies of distillers dried grain, a high protein by-product, reduced the demand for soybeans thereby reducing the acreage planted to soybeans.

While the production of alcohol from agricultural crops may be politically and economically attractive, there are also potential problems. Unless the cost of alcohol production becomes more competitive with that of petroleum, large federal and state subsidies would be required to encourage gasohol production. Currently these subsidies are about $0.50 per gallon of ethanol. In the context of the Meekhof, Tyner, and Holland study, this would imply a total annual gasohol subsidy of $0.5 to $2.0 billion. For comparison, total government farm program payments in 1978 were $3.0 billion—the highest level since the late 1960s and early 1970s.

Another concern raised by some is the potential conflict of food versus fuel production. Brown argues that there could be a massive diversion of agricultural resources to energy production at a time when efforts to expand world food output are losing momentum, food prices are increasing, and malnutrition is increasing in some less developed countries. However, most of the poor people in the less developed countries are employed in agriculture and could benefit from higher farm commodity prices if their governments do not follow cheap food policies which distort market prices.

Current U.S. ethanol production facilities are designed to use corn as a feedstock. During the 1980s other feedstocks are likely to increase in importance. Diversification of feedstocks to lower-cost, nonfood sources should reduce the conflict of food versus fuel. Also, there should be less soil erosion as biomass replaces corn as the principal feedstock.

Major efforts to stimulate gasohol production in the decade ahead will require reexamination of current farm policy including supply management programs, export policy, food aid efforts, and price stabilization policies. A major challenge to policy makers will be to provide subsidies and policies that are sufficiently flexible to provide adequate incentives to expand food and fuel production without causing significant land and environmental deterioration or undue hardships on low income consumers, particularly in the less developed countries.

Structural Debate

The structure of American agriculture has been a source of concern for many for several decades. Structural change has been occurring among the agricultural marketing industries as well as in the economic organization of agricultural production. The marketing concerns include imperfect competition, increased concentration, and market power. These will continue to be important policy issues in the 1980s but lie beyond the scope of this article.

The most commonly cited structural problem is farm size and the concentration of agricultural production (Stanton). Since 1950 the number of farmers in the United States has declined by half and the average farm size has more than doubled (USDA). Gardner (1980) has shown that in 1978 the smallest 40% of U.S. farms accounted for less than 2% of sales, while in 1940 the smallest 40% produced 8% of the sales. In contrast, the largest 20% in 1978 produced 80% of sales, while in 1940 they produced 64% of sales.

Many factors have contributed to structural change. They include: technical change in farm production, changes in product and factor markets, tax laws, macroeconomic policies, the competitive nature of the sector, and farm commodity programs (Gardner 1978).

Several studies have documented the distributional implications of farm commodity programs on farm structure (Bonnen; Schultze; Lin, Johnson, Calvin). Because subsidies or deficiency payments are based on production, larger farmers receive larger payments. In 1978, almost half of the $2 billion of deficiency payments went to 10% of the farm program participants—those with larger farms. By contrast, 50% of the farms—the smaller units—received only 10% of the payments. Thus, farm commodity programs have

increased the inequality of the distribution of income in agriculture. What is not clear is the extent to which commodity programs have changed farm structure.

Some argue that price support programs increase average size and concentration of farm production units. It is hypothesized that high price supports generate windfall gains for the larger producers enabling them to outbid smaller producers for land. However, conceptually, the optimal size of a competitive firm (assuming perfect markets) is independent of product price. With imperfect capital markets, small operations may reap less benefits than larger ones from high price supports.

It has also been argued that farm programs reduce price risk (Pope and Gardner). Risk reduction can increase specialization. Net farm income as a percentage of total income is greater on larger-scale operations. Thus, price stabilization by means of farm commodity programs could encourage a shift to larger-scale, specialized farms.

On the other hand, it has been argued that farm commodity programs make it possible for smaller, higher-cost farmers to stay in business (Gardner 1978). Price supports help cover variable costs and increase the returns to fixed resources. In fact, this has been one of the historic justifications of farm programs.

In the 1970s there was considerable rhetoric to reduce payment limitations. Few participating farmers (0.2% in 1978) have been affected by payment limitations. Efforts likely will continue to limit payments to larger producers. Alternative arrangements include graduated target prices which favor small producers or even no target price support for the larger producers.

The level and stability of commodity prices may influence future structural change, e.g., price support programs can result in higher land values and alter land ownership patterns (Boehlje and Griffin). However, tax policy, credit policy, and the rate of technological change may have greater impacts on future changes in farm structure than farm commodity programs.

Reconciling the New Policy Agenda

Efforts to reconcile the policy objectives and issues raised in this article all impinge on changes in land policy. Thirty years ago Schultz first noted the declining relative economic importance of agricultural land as new production technologies were being adopted. A continuing stream of new energy-and-land-saving technologies will be necessary in the decade ahead if growth in agricultural output is to match the expected expansion in agricultural demand without major increases in real commodity prices. Even then, agricultural land policy will be an important policy issue. (Other related land policy issues include foreign and corporate ownership and the continued shifting of prime agricultural land into nonagricultural uses.)

Restrictions on pesticide and fertilizer use to meet new environmental standards tend to reduce land productivity. At the same time, expanding export demand coupled with efforts to produce ethanol derived from energy crops is encouraging expansion of agricultural production and bringing more land into production. This increases the threat of further soil erosion and environmental pollution.

Rising land values have exacerbated farm structure problems (USDA). Beginning farmers are finding it increasingly difficult to acquire sufficient capital to enter farming. Established farmers are confronted with complicated estate-planning problems and potentially high capital gains taxes. Future increases in real commodity prices will result in even higher land values and further structural change.

The challenge to researchers and policy makers is to develop simultaneously a new conceptual framework and new institutional arrangements to deal with the various issues on the emerging food and agricultural policy agenda of the 1980s. Historically, agricultural policies have been analyzed and legislation has emerged in a rather eclectic fashion. And, existing government agencies and institutions were designed to cope with problems of excess capacity and agricultural surpluses, not problems of resource scarcity.

Efforts to expand agricultural production to meet growing food and energy demands without causing serious environmental damage will require a much more integrated policy approach at the federal, state, and local levels. Land ownership and its use is likely to form the crux of the food and agricultural policy challenge of the 1980s.

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The Farmer-Owned Reserve: How Is the Experiment Working?

William H. Meyers and Mary E. Ryan

The volatile behavior of grain markets in the early 1970s sparked discussions and research on policies to stabilize grain markets and assure food security. The U.S. farmer-owned grain reserve, instituted in 1977, is an outgrowth of those debates and studies. The reserve has functioned for three years, and a preliminary appraisal can now be made. In this paper, we briefly review the background and provisions of the program in sections one and two; focus on farmers' response to the program and implications for grain markets in sections three and four; and finally, look at problems and prospects for the future.

Background

Instability has become particularly acute in the U.S. grain economy because of the increasing level and variability of U.S. exports, the insulation of important foreign markets from world price fluctuations, and the reluctance of the United States to erect trade barriers to protect domestic markets. Thus, good and poor growing conditions around the world and policy shifts by trading partners and competitors have a destabilizing impact on U.S. grain markets. Because weather and other nations' policies are beyond the control of the United States, other means must be sought if the government desires to alleviate the consequences of destabilizing influences. The literature is rich with studies on the welfare effects of stabilization and on national and international stabilization schemes (Houck and Ryan). Our purpose is not to debate these issues or alternatives but to study the one stabilization program that has been given a trial run.

The U.S. farmer-owned grain reserve (FOR) was instituted for wheat and rice on 4 April 1977, after several weeks of intensive planning by the Carter administration. Although the administration acted under authority of existing legislation, Congress affirmed the action by mandating a producer-owned program for wheat and rice and by authorizing a similar feed grain reserve in the Food and Agriculture Act of 1977 (Johnson). These actions made the FOR the first serious U.S. experiment with a managed, national reserve program.

In making annual decisions about the grain reserve and other crop program provisions, the administration's goal is a total grain carryover of 6%–7% of world consumption. Currently, this means targets of about 1,100 and 1,500 million bushels for wheat and corn, respectively. In addition to the FOR, the other major program for managing grain supplies is the acreage set-aside. The annual nonrecourse loan and concessional export programs are also part of the package. Under current market conditions, the FOR has a central role because, among these instruments, only it can provide some protection against shortages.

Program Provisions

Nine-month, nonrecourse loans and three-year FOR loans are both available to eligible farmers (those in compliance with crop programs) at the loan rate specified for the crop under contract. Farmers retain ownership of grain used as collateral for such loans. There the similarities end. The major added benefit of the FOR is an annual storage subsidy payment approximately equal to commercial storage costs in major grain-producing states. Since March 1978, FOR loans have also been interest-free after the first year. The interest

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charge was waived completely on 1979 crop contracts signed after the 1980 embargo of grain shipments to the USSR.

The major added constraints are those that control the redemption of reserve grain. The nine-month loans may be redeemed at any time. Voluntary redemption of FOR grain is permitted only after farm prices reach a specified "release level." After the second consecutive monthly release, storage payments may be suspended.[1] Redemption is mandatory when farm prices reach a specified "call level" or the contract expires. If the loan is not repaid within a specified period (currently ninety days) after it is "called," the grain is forfeited to the Commodity Credit Corporation (CCC). Although the initial loan rate is fixed, the release and call triggers for all contracts are a fixed percentage of the current loan rate, which normally increases over time. The minimum release price for CCC-owned grain is currently 5% above the call level of FOR grain, making CCC inventories a reserve of last resort.

Initially the FOR option was available to a farmer only after his nine-month loan matured. This requirement was relaxed selectively in 1978 and finally was removed completely for all crops in October 1979. Now direct entry to the reserve is permitted except when it is in "call" status or has reached a quantity limit that may be set by the Secretary of Agriculture. This change is important, because it makes reserve quantities more responsive to current market conditions.

In summary, a flexible set of incentives and disincentives is designed to induce farmers to place grain in the reserve when market prices are near or below the release level and to redeem grain when prices are between the release and call levels. The government has no control over the farmer's decision to sell or hold the grain after it is redeemed, although in many cases a cash sale may be required to repay the loan. The FOR participant sacrifices some control over the reserve grain in exchange for a substantial reduction in carrying cost and risk.

Farmer Response

Farmer response to the FOR program involves decisions on whether or not to participate, the level of grain placements, whether or not to redeem grain when it is released, and the amount to be redeemed. A farmer's placement and redemption decisions are influenced by the program provisions, grain use options, price expectations, storage costs, and factors that affect risk-bearing ability.

An aggregate response of farmers to the reserve program can be conceptualized based on the factors influencing the individual decision (Meyers and Jolly). Placements are likely to be small at prices near the release level and increase monotonically as price falls. Similarly, for prices above the release level, redemptions are expected to increase as price rises. These price-quantity relationships add a new component to farm inventory behavior, related to but quite different from demand for "free" stocks. Very little is known about the parameters of these relationships, but it is clear that the response elasticities are influenced by program provisions and farmer expectations.

Annual data on wheat and corn reserve operations provide evidence of farmer response as program provisions and market conditions have changed (table 1). By the end of 1977/78, substantial quantities of both grains had been placed in the reserve, although early placements were sluggish as farmers waited for nine-month loans to mature.

Wheat placements were small in 1978/79, when prices were closer to the release level, and 1978-crop wheat was not eligible for direct entry. Wheat was released in May 1979, and storage payments were halted on 30 June. More than 200 million bushels were redeemed (most before loan and trigger levels were raised in January), but substantial quantities remained in the reserve without the benefit of storage payments. Prices during the heavy release activity were well above the \$3.29 release level; but after the trigger levels were raised, new placements occurred, and the net decline for the year was 143 million bushels. Wheat loan and trigger levels have been raised substantially for 1980/81, so a few placements are anticipated in spite of a higher price level.

The release and call levels for feed grains were set to span a smaller range than that for wheat, largely to moderate input price variability in the livestock industry. One result of the narrower trigger range is more frequent movements in and out of release status for corn (and even more for minor feed grains).

The average price of corn in 1978/79 was

[1] Payments stop if the difference between state price and loan levels is greater than the difference between the national release and loan levels.

Table 1. FOR Placements, Redemptions, Net Change in Reserves, Prices, and Trigger Levels, 1977/78 to 1980/81

	1977/78	1978/79	1979/80[a]	1980/81[a]
	(million bushels)			
Wheat				
Total placements[b]	342	51	67	n.a.
Total redemptions[b]	0	0	−210	n.a.
Net FOR change	342	51	−143	20
Net CCC change	48	2	150	−10
	($/bushel)			
Farm price	2.33	2.98	3.82	4.08
Call level[c]	3.94	4.11	4.38–4.63[d]	5.25–5.55
Release level[c]	3.15	3.29	3.50–3.75[d]	4.20–4.50
Loan rate	2.25	2.35	2.50[d]	3.00
	(million bushels)			
Corn				
Total placements[b]	315	425	350	n.a.
Total redemptions[b]	0	−200	−140	n.a.
Net FOR change	315	225	210	−750
Net CCC change	12	88	160	0
	($/bushel)			
Farm price	2.02	2.25	2.50	3.25
Call level[c]	2.80	2.80	2.94–3.05[d]	3.15–3.26
Release level	2.50	2.50	2.63[d]	2.81
Loan rate	2.00	2.00	2.10[d]	2.25

[a] USDA estimate, 12 Sept. 1980. Midpoint of price range is used for 1980/81.
[b] Estimates based on monthly USDA reports.
[c] Due to changing provisions, contracts have differing trigger levels.
[d] The 1978/79 levels prevailed until 7 Jan. 1980.

midway between the release and loan levels, and FOR carryover increased by 225 million bushels. In 1979/80, net placements are expected to be about the same, although the average price is near the release level. In both years placements were large during the first nine months. In early 1978/79, direct entry was temporarily permitted while prices were depressed, attracting more than 400 million bushels to the reserve. Late in the year corn was released for less than two months, and nearly 200 million bushels were redeemed. Corn was released again in October and November 1979, but there were few redemptions.

Direct entry became a general provision of the FOR in October 1979, so placement of 1979 corn began early in the year. The rate of placements increased as local grain markets weakened and more attractive reserve provisions were announced after the January 1980 embargo. Loan, release and call levels, and storage payments were increased moderately, and interest payments were waived completely. However, FOR placements were not sufficient to meet the administration's commitment to offset the market effects of the embargo. In April, FOR loans were offered with interest to farmers who did not participate in the 1979 set-aside. By the end of June 1980, about 350 million bushels of corn had been added to the reserve. In July, as prices rose in response to poor weather conditions, corn was released for the third time. Current estimates anticipate redemptions of 140 million bushels by the end of the crop year.

The corn reserve is likely to undergo its first real test under shortage conditions in 1980/81, when average price is expected to be above the "first" call level. By current estimates, the corn FOR will be exhausted before October 1981, and CCC stocks will remain intact.

Both wheat and corn farmers have responded to program incentives, and the pattern of their response is clearly affected by changing program provisions and market conditions. Placements were constrained in 1977/78, but in other years have occurred at prices well above loan rates, especially when direct entry was permitted. Redemptions sometimes have occurred at prices well below call levels, but many farmers continue to hold reserve grain in anticipation of higher prices even when storage payments are suspended.

The Secretary of Agriculture has broad discretionary authority over program provisions, which can raise or lower the rate of response.

Yet, program administrators must operate with a substantial degree of uncertainty about farmer response and, consequently, about whether program objectives can be achieved. This uncertainty leads to frequent tinkering with program provisions when the desired response is not forthcoming.

Market Implications

Two major objectives of the FOR are to stabilize price variability within a fairly broad range and to increase the reliability of U.S. supplies for export and domestic use. The FOR adds a price-responsive component to the market and thus increases the elasticity of total market demand when the FOR is open for placements or redemptions. Clearly this has the effect of reducing price variability both across years and within years. By the same reasoning, the FOR increases the elasticity of export supplies. Thus the operation of the FOR creates a fundamental change in the structure of grain markets, which alters the market impact of shifts in government policies and other exogenous shocks. We employ a simple annual model to explore the interaction of the FOR with market supply and demand and to generate a preliminary estimate of the impact of the FOR on corn and wheat markets from 1977/78 to 1980/81.

For comparison purposes, an alternative policy assumption is needed. The 1977 Act provides an alternative policy for feed grains, and we will assume the same for wheat—a nonrecourse loan program with a CCC release level of 115% of the loan rate.[2] All other policy decisions are held constant in this analysis.

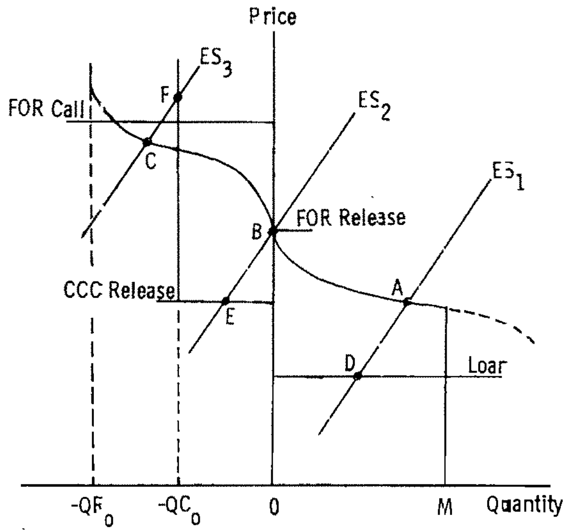
The interaction of the FOR with annual market supply and demand is illustrated in figure 1 and compared with that of the alternative nonrecourse loan program. Annual net placement behavior for the FOR is represented by a truncated "s"-shaped function in the positive quadrant. It is truncated by the constraint on new placements (M) that may be imposed by the Secretary of Agriculture. Annual net redemptions are represented by an "s"-shaped function in the negative quadrant. The level of reserves at the beginning of the year (QR_0) limits total redemption. The alternative program is represented by a perfectly elastic government demand at the loan rate and a perfectly elastic "supply" at the CCC release level. The latter is constrained by the beginning level of CCC stocks (QC_0).

The equilibrium price in this model is determined by the intersection of a stochastic excess market supply (ES_i) with the appropriate reserve stock relationship. If the release price is set at the long-run market equilibrium, the expected excess market supply is represented by ES_2 where free supply and demand are in balance at prices near the release level and there is little FOR activity. In this context, ES_1 and ES_3 represent the variability of excess market supply given world surplus and shortage conditions, respectively. If there is a market surplus, reserves are accumulated by the FOR at prices between the release and loan rate (point A). A shortage in the market leads to redemption and sale of FOR grain at prices between the release and call levels (point C), although the illustration shows that not all sales necessarily occur below the call level.

It is clear that the range of price variability under the FOR program is not determined by the loan and call levels but depends crucially on the factors that determine the response functions. These functions may lie above or below those illustrated in figure 1. For example, if the FOR provisions are attractive and long-term price expectations are high relative to current prices, reserves may accumulate rapidly and hold prices well above the loan rate. If price expectations are weak and the disincentives for holding grain at prices above the release level are large, redemptions may occur rapidly and keep prices well below the call level.

With only the CCC inventory program, the given range of market conditions (ES_1 to ES_3) is likely to generate a wider range of equilibrium prices than that obtained with the FOR. Under the surplus scenario, price would be near the loan rate, more grain would be consumed, and less stockpiled (point D). Because less accumulation occurs during surplus periods, the reserve would in general provide less protection in periods of severe scarcity (point F). There are several caveats to this generalization. First, the extent of divergence between points A and D or points C and F depends on program provisions and the other factors that influence the FOR response func-

[2] The 1977 Act sets the CCC release level for feed grains at 115% of the loan rate if the Secretary of Agriculture does not activate the FOR. This alternative also represents a practical minimum level of government intervention under which government inventories accumulate only through loan defaults and are released as soon as possible thereafter.



ES_t is production plus beginning free stocks less total demand for domestic consumption, exports, and free stocks; M is government limit on new placements; QR_0 is FOR stocks at beginning of year; QC_0 is CCC stocks at beginning of year.

Figure 1. The farmer-owned reserve and alternative CCC programs under differing supply and demand conditions

tion. Second, without the FOR, the administration and Congress would be under greater pressure to raise loan rates and increase crop set-aside when surplus conditions exist. Third, the graphical comparison is static rather than dynamic and does not take into account the effect of reserve stocks on free stock levels or the effect of altered prices on production.

In the dynamic analysis below we continue to hold other policy actions constant but take account of the production response to changing price levels and the effect of reserve stock levels on free stock demand. Although we do not know the position of the FOR response curves, the annual historical observations define points such as A, B, and C on these unknown relationships. From these observed points, we generate points such as D, E, and F under the alternative program by assuming price elasticities for the components of excess market supply.

The five-equation model abstracts from all supply and demand shifters except FOR and CCC-owned stocks. The latter are assumed to influence private inventory demand.

(1) Excess market supply (identity):
$$ES_t = QP_t + QI_{t-1} - QD_t - QI_t$$
(2) Domestic and export demand:
$$QD_t = D(P_t)$$
(3) Ending free stock demand:
$$QI_t = I(P_t, QR_t, QC_t)$$
(4) Equilibrium condition (identity):
$$ES_t = QR_t - QR_{t-1} + QC_t - QC_{t-1}$$
(5) Production response:
$$QP_{t+1} = S(P_t),$$

where P is market price, QC is ending CCC stocks, and QR is ending FOR stocks.

In 1976/77 both FOR and CCC inventories were zero, so our analysis begins in 1977/78. FOR stocks are reduced to zero in each year, and the operating rules for the alternative program are imposed.[3] These changes affect current utilization, free stocks and price; the last influences production for the following year. The price elasticities assumed for consumption, free stocks, and production are −.3, −1.0, and 0.2, respectively.

The effects of FOR and CCC inventories on free stock demand ($I_2 = \partial I/\partial QR$, $I_3 = \partial I/\partial QC$) are important in this analysis, and few empirical measures are available. Clearly if these coefficients are −1.0, the operation of a reserve has no effect whatever on total stocks or on price. Gardner demonstrates with an optimization model that public stockpiling reduces the expected gains from private storage and thereby reduces private stock demand. Empirical estimates of the shift in free stock demand caused by such an expectations effect for CCC inventories range from −.32 per bushel for corn to −.09 per bushel for wheat (Gallagher et al., Baumes and Womack). Because of the wider band between the loan rate and release prices for both FOR and CCC grain under the current program, the expectations effect may well be smaller than the historical estimates indicate. On the other hand, there may be added effect from farm level substitution between FOR and free stocks. The short data series preclude precise estimates of these effects, but the first such estimate by Sharples and Holland indicates an aggregate substitution effect of −.13 per bushel for FOR wheat. They attribute this effect to an on-farm substitution between FOR

[3] To "hold other policies constant," we take the actual year-to-year change in CCC stocks (ΔCCC) as given. (This is necessary to account for special purchases after the Jan. 1980 embargo.) Then,

$$QC_t = QC_{t-1} + \Delta CCC,$$

unless the equilibrium price falls below the loan or rises above 115% of the loan; QC_t increases to "protect" the price floor and decreases to "protect" the release level until reserves are exhausted.

and free stocks, but it also could be partly or entirely a measure of the expectations effect. Our analysis assumes that $I_2 = I_3$ and uses coefficients of $-.2$ and $-.4$ to provide a fairly conservative range of FOR impacts.

The results for the period 1978/79 to 1980/81 are summarized in table 2.[4] For both crops the elimination of the FOR results in a higher price variance, lower total stocks, lower reserve levels, and higher free stocks. Effects on production over this period were relatively small, but the changes in stock levels were substantial. Without the FOR, grain stocks as a percentage of utilization in 1980/81 would approach the levels experienced in 1973/74 for corn and 1974/75 for wheat, and all reserves would be exhausted. As expected, a smaller impact is obtained when a higher rate of substitution ($-.4$) between reserves and free stocks is assumed.

In the case of wheat, average annual stock levels are 200 to 240 million bushels lower without the FOR, and free stocks are 100 to 200 million bushels higher. Average reserve levels with the FOR account for nearly half of total stocks. Without the FOR, reserves are very small, because the lower release price of $2.70 allows reserves to decline in 1978/79. What remains is exhausted in 1979/80. Wheat prices without the FOR are about $.30 lower in 1978/79 and $.50 to $.80 lower in 1979/80, but a sharp rise in prices occurs in 1980/81 as stocks are drawn to near pipeline levels.

Corn without the FOR shows a 180 to 230 million bushel decline in average annual stocks and a 70 to 130 million bushel increase in free stocks. Average reserve levels with the FOR make up nearly half of total stocks. With no FOR, reserves are about 300 million bushels lower on average and all reserves are exhausted in 1980/81. Prices without the FOR are lower in the two years of surplus but rise sharply in 1980/81 to levels above the FOR call price.

The impact of the FOR on average price seems to be significantly greater for wheat than for corn, in part because wheat trigger levels have escalated more rapidly. This is also reflected in the four-year total value of farm production, which was 10% to 15% higher for wheat with the FOR and 2% to 3%

[4] Although 1977/78 was included in the analysis, FOR activity was not significant until the latter half of the year and had little impact on prices or stock levels. FOR placements essentially replaced CCC defaults in 1977/78, so this did affect the realized value of farm production.

Table 2. Stock and Price Levels with the FOR Compared to Estimated Levels under Alternative CCC Program with Different Rates of Substitution between Reserve and Free Stocks ($-.2$ and $-.4$)

	Wheat			Corn		
		No FOR			No FOR	
	With FOR	(−.2)	(−.4)	With FOR	(−.2)	(−.4)
	(million bushels)					
Mean levels 78–80						
Production	2,084	2,039	2,051	7,128	7,078	7,091
Ending stocks	925	685	733	1,286	1,053	1,107
Free stocks	474	593	660	649	723	781
FOR stocks	304	0	0	430	0	0
CCC stocks	147	92	73	207	330	326
1980–81 stocks						
Total	948	583	675	871	628	686
All reserves	460	0	0	260	0	0
	($/bushels)					
Farm price						
1978/79	2.98	2.70	2.70	2.25	2.10	2.14
1979/80	3.82	3.03	3.34	2.50	2.41	2.42
1980/81	4.07	4.05	4.06	3.25	3.44	3.41
Mean	3.62	3.26	3.37	2.66	2.65	2.66
Std. deviation	.47	.57	.56	.42	.57	.54
	($ billion)					
Farm value of production 1977–80[a]	28.5	24.8	25.6	70.3	68.6	68.9

[a] FOR grain is counted in the year of sale; wheat reserves remaining in 1980/81 are valued at the release price.

higher for corn. Higher farm prices are partially offset by lower deficiency payments for wheat in 1978 and 1979 and for corn in 1978. Payments over this period under the alternative policy would have been $400–$700 million higher for wheat and about $300 million higher for corn.

The price-enhancing effects of the FOR during surplus periods benefit all farmers regardless of program participation. Similarly, all farmers feel the price-depressing effects during periods of shortage when reserves are released. FOR participants gain added benefits through their storage operations, because they are able to carry grain from surplus to shortage periods at little or no cost. According to a recent survey of corn and wheat farmers, the benefits of participation accrue primarily to large farms with large cash grain operations (Meyers, Jolly, Ryan).

For the purpose of clarity, a simple model was used for this analysis. The model could be refined to include cross-commodity effects among grains and other crops and the interaction with livestock markets. On balance, the omission of these factors results in relatively conservative estimates of the FOR impacts.

Problems and Prospects for the 1980s

The farmer-owned reserve experiment has shown that this kind of cooperative reserve program, combining private incentives and public intervention, is a viable approach to stabilization. It has reduced price variability and increased annual carryover stocks consistent with stabilization and security objectives. Intended or not, it also has raised the average price of wheat and the farm value of production for wheat and corn over the period. The price-enhancing effect of the program in surplus years has shifted some of the income support burden from the target price system (the taxpayer) to the market (the consumer). The consumer, in turn, benefits from lower prices in years of shortage. The experimental phase will not be complete until it is tested during a period of shortage. In addition, there remain operational issues and questions of objectives to be resolved.

As with any new program, there have been numerous implementation problems with the FOR. With experience, such problems are being rectified. A major constraint to the responsiveness of reserve placements to market conditions was removed when direct entry was made a general provision, effectively severing the link between the annual loan and FOR programs. One remaining potential constraint is the requirement that participants be in compliance with announced set-aside programs. This can leave the FOR with an inadequate operating base when set-aside participation is low, as was the case with corn in 1979/80. The release and call mechanism has yet to be tested under severe shortage conditions, although 1980/81 corn may be such a test. It may be necessary to impose additional disincentives to encourage redemption between the release and call levels and insure an orderly release of grain within this range of prices.

A key issue is whether the FOR will be used strictly to stabilize prices around the long-run market equilibrium or to raise equilibrium price levels. The wheat analysis indicates a tendency toward using the FOR as a price and income support mechanism. Some policy leaders have supported using the release price to keep market prices in line with farmers' production costs. Depending on the choice of "production costs," such a policy could transform the FOR into a high price support mechanism if release levels are set above market equilibrium prices. It would move distinctly away from the direct payments approach and return to increased reliance on consumers for supporting farm income. It would require greater reliance on acreage controls and threaten to revive all the well-known problems associated with supporting prices above market equilibrium levels.

A pure stabilization approach to the FOR would require setting release levels near long-run market equilibrium prices while continuing to use direct payments, if necessary, for income support. There would be little or no need for a set-aside program. Of course, these approaches do not differ if long-run market conditions are such as to keep equilibrium prices rising with farm production costs.

Finally, there is the question of size and stabilization objectives. The anticipated emptying of the corn reserve in 1980/81 indicates the limited protection afforded by current stock objectives. Moreover, the current reserve mechanism does not provide any assurance that the United States can respond to emergency food needs of the third world in periods of scarcity, and a special emergency wheat reserve for this purpose has awaited congressional approval since 1977. If the

United States continues to operate the reserve unilaterally, it must decide how much stability and food security will be provided and for whom. Will world prices be stabilized or only U.S. prices? Will the supply security objective include all export customers, a select few, or only the United States? Answers to these questions will determine the required size and cost of the reserve and whether or not it is necessary to adopt other measures, such as export management (Cochrane, Martin, Spitze) to achieve the objectives.

There is every indication that a farmer-owned reserve in some form will continue to be an important instrument in food and agricultural policy in the 1980s. It offers a mix of stabilization and security benefits and a blend of government and private control that have won broad support in Congress and is palatable to many farmers. But the FOR is a flexible policy instrument. How the program is used will depend to a great extent on who controls the program and what objectives are established to guide its operation.

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A Framework for Food and Agricultural Policy for the 1980s

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Four broad subjects, or areas, will dominate food and agricultural policy discussions during the 1980s. They will not necessarily be prominent in the debate on the 1981 farm bill, however, because they may develop slowly during the decade. The areas are as follows:

(*a*) A perceptible shift toward commodity shortages and rising real prices for agricultural commodities as the norm for the food and agriculture sector. The food and agriculture policy agenda during the 1980s will be determined largely by the way this situation develops.

(*b*) The declining role of price and income supports and production-adjustment programs, long the mainstream of federal agricultural policies. They will remain in the law but will be greatly diminished in importance. Occasional commodity surpluses may still require attention, however, in a general climate of strong demand and rising real prices for food and agricultural products.

(*c*) How to cope with shortages and rising real commodity and food prices to the satisfaction of farmers, domestic consumers including new users, foreign customers, and budget planners will become the mainstream of domestic and international agricultural policy.

(*d*) A grab-bag of concerns, including how to get beyond rhetoric in the discussion of farm size, farm and rural life, and other areas that have been collected under the heading of farm structure; how to bring the price support and marketing programs for dairy products closer to the mainstream of food and agriculture policy; how to manage the increased demands on land and water and reinvigorate land and water conservation programs at the same time; how to get other nations to provide a portion of the world's grain reserve; and a host of agricultural policy trivia including how to estimate cost of production, what to do with the estimates, how to set loan and target prices that farmers will have little interest in, how to operate our reserve programs without making them entirely incomprehensible, whether the food stamp and school lunch programs are agricultural or welfare programs, how to proceed on various food safety issues in the wake of the abortive nitrite experience, among others.

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The Shift to Commodity Shortages

The 1960s and 1970s were dominated by commodity surpluses, with occasional mild remissions and one three-year period of severe shortages. Even in that period, the real price of corn in the U.S., for example, rose slightly, as did the index of prices received by farmers for farm products marketed. During the 1970s, food price increases became a significant factor in overall inflation for the first time in the twentieth century, apart from war periods.

My view of the world in the 1980s, assuming it is relatively peaceful and modestly prosperous, is that demand for agricultural resources and commodities, especially land, technology, livestock products, and grains and oilseeds, will be very strong. Some developing nations will neglect their agriculture because they have oil to sell; others will eat their agricultural successes as rapidly as they achieve them and will need still more food. Rising incomes in relatively advanced developing countries will cause the demand for livestock products to outstrip their own food production. The demand for grain and other agricultural products for use as energy and sweetener feedstocks will add to an already strong overall demand.

Real prices of agricultural products seem likely to rise under such circumstances, both to help ration the limited agricultural products among various users, nations, and processes, and to let farmers know that more production is needed. Managing and responding to this phenomenon will represent a continuing chal-

lenge. It will change what agricultural officials worry about from day to day, both in the United States and abroad. It need not require a vast array of new programs or a new army of administrators in the Department of Agriculture, however.

Price and Income Supports and Production Adjustment Programs in an Era of Commodity Shortages

These programs have been the mainstream of food and agricultural policy for many years, but they will not retain that position during the 1980s. Experience from the 1970s tells us that conventional price and income support and production adjustment programs will be mothballed, not discarded, under the circumstances postulated for the next decade. If conditions change for a few years for one commodity or another, some of these programs may be needed again. The basic farm program instruments, such as price support loan and purchase programs, authority to limit acreages of major crops, and to store and later dispose of surpluses, probably will be continued for a decade or more, even in the economic climate I have suggested. Intense but usually meaningless debates will erupt occasionally in USDA and among farm groups over loan and target price levels and acreage diversion programs. They seldom will be important.

Managing Shortages of Agricultural Resources and Commodities

This area will become the mainstream of food and agriculture policy during the 1980s. Its principal components will be grain reserves and export arrangements. Adoption of a program in 1977 to isolate certain amounts of grain from the market until prices rise well above support levels represents an important beginning toward managing shortages in the 1980s. That program is now the principal price support program for grains, a fact that is not yet clear to farmers or to the marketplace. It helped stabilize prices in 1980 and will provide the government some time to prepare for the more direct actions that may be required to help achieve national economic objectives in case commodity shortages are as severe and as chronic in the 1980s as surpluses were in the 1950s, 1960s, and half the 1970s.

U.S. experience in managing commodity shortages in peacetime has been chaotic. It began in 1973 with official misstatements of actual U.S. policy regarding the possible use of export controls. Promises were made never to limit exports, followed by imposition of export embargoes (the worst form of export restraint) for certain agricultural commodities when shortages appeared to be more severe than had been expected.

The ability and willingness of the United States to limit the volume of exports of feedstuffs, especially to countries with high meat diets, and the means by which such limits would be applied may become key elements in maintaining adequate supplies of grain for all domestic uses at reasonable and competitive prices: (*a*) if the demand for grain generally outpaces increases in production; and/or (*b*) if poor harvests in a number of seasons dissipate reserve stocks in the 1980s.

Since it has long been U.S. policy to expand the volume of agricultural exports, it will require a major effort by the U.S. government and by farm groups to address the question of limiting exports rationally while maximizing export earnings from reduced shipments. The relatively recent introduction of domestic price stabilization to the list of objectives governing U.S. agricultural exports and the addition of sweeteners in the 1970s and ethanol production in the 1980s as high priority domestic uses for grain are a threat to the achievement of the traditional objectives of export policy. The recent use of agricultural exports as a diplomatic tool has taken us even further from past hopes and practice in regard to farm exports.

In this climate, the development of arrangements with a number of countries under which the United States would agree to supply a certain volume, but not unlimited quantities, of food exports seems likely to become a major element of agricultural and trade policy. Such an effort would lead inexorably to limits on the volume of exports under certain circumstances as a matter of policy.

The United States has had a policy for many years to limit exports for economic, national security, and foreign policy reasons. Policy in respect to the use of restraints on agricultural exports was stated in the report dated 25 May 1976 of the Senate Committee on Banking, Housing, and Urban Affairs (to accompany S. 3084), and the report of the House of Representatives Committee on International Rela-

tions dated 2 September 1976 (to accompany H.R. 15377). As stated in the Senate report:

> Under the Export Administration Act, it is expressed U.S. policy to use export controls, including controls on agricultural commodities, for both foreign policy and national security purposes, as well as for purposes of protecting the domestic economy from the excessive drain of scarce materials and reducing the serious inflationary impact of foreign demand.

This bipartisan policy was informally ratified during the 1976 presidential campaign. Candidates Carter and Dole emphasized their determination to avoid the use of export controls on agricultural products wherever possible, but cited the need to use such controls whenever the national interest required it or when serious shortages threatened undue inflation in the United States.

The language of the Export Administration Act seems to provide for authority to limit the export of agricultural commodities, using supply or price stabilization criteria. However, the wording of the Act is ambiguous, stating that exports may not be limited for that purpose if supplies of the commodities in question exceed domestic needs. A practical interpretation of the Act would require the Secretary of Agriculture to make allowances for expected export levels before judging if the remaining supply is adequate for all domestic uses, presumably at acceptable prices. This language will require early clarification if the conditions I have described for the 1980s prevail.

It may be necessary sometime during the 1980s to determine and announce the conditions under which agricultural exports will be limited on a continuing basis in pursuit of domestic price stabilization objectives and a fair apportionment of our export supplies among all claimants, including adequate supplies for feeding and industrial uses in the United States. This would require a fundamental modification of our policies and our rhetoric on free and unlimited exports and of our position as a reliable residual supplier. It would precipitate a big political fight.

Our methods of pricing agricultural exports surely would come into question under such conditions, as larger export earnings become essential and possible. Relatively short supplies will increase market prices, and that would add to export earnings through the market. However, the possible need to think the unthinkable and to design procedures for selling our products into a very demanding world market at a premium over prices prevailing in the United States should not be overlooked. I do not refer here to some kind of federal export board or corporation. Such a procedure is out of character with our history, is demonstrably beyond the ability of our government to manage, and is not needed because present law and existing private marketing institutions could quickly adapt to modest revisions in our export marketing methods.

Other Policy and Program Issues

Farm structure is important even if the results of its consideration are mostly talk and the thrill of participation. Perhaps some steps can be taken in the 1980s to get this issue beyond rhetoric and to help a few thousand farmers. We have known for thirty years that big farmers get most of the commodity program benefits, that displacement of small farmers often was accelerated by federal programs, that a very small number and percentage of farmers market most of our food commodities, and that certain people are more aggressive than others in using debt and the tax laws to ease their relatives and neighbors out of farming. The clock will not be turned back by policy measures on fifty years or more of farm technology, farm consolidation, and the abandonment of small towns and other rural infrastructure built by our grandfathers. But incentives that speeded farm consolidation can be limited or removed, help can be provided for a few more young and small farmers, old farmlands can be reclaimed, and new energy and fertilizer sources can be encouraged. Such measures are important, but they will have little relationship to commercial agricultural production in the 1980s.

Neither the price support program nor the marketing order program for dairy products is in harmony with the programs for other major agricultural commodities. Since the 1960s, continuous efforts have been made by Congress and several administrations to reduce the level of government activity affecting major commodity markets, especially grains and cotton. Restraint in increasing price supports has resulted in market prices generally above support prices for most other commodities. These program changes were made to take account of the changing structure of these producing sectors and of gains in production

efficiency, to compete more actively for world markets, to provide more opportunity for market forces to perform their traditional functions, and to insulate the overall economy from inflationary impacts arising from agricultural price and income support programs.

Congressional action and administration lethargy in recent years have moved dairy policy in the opposite direction. Milk programs are visibly inflationary, and this needs to be remedied in the 1980s. It is a curious anomaly that when grain and soybean prices move well above support levels, federal programs are shelved and forgotten; but when milk prices do the same, it is taken as a signal to raise support levels. It will require a hard political fight to modernize the milk programs some time in the 1980s, but it needs to be done.

A Framework for Analyzing Agricultural and Food Policy in the 1980s

Dale M. Hoover

In a recent paper my colleague E. C. Pasour presented an incisive review of the effects of recent public policy in agriculture. He noted that there have been large transfers from consumers to producers, that these benefits have tended to be concentrated among farms with larger-than-average sales, that benefits frequently have been capitalized—leaving present farmers with little benefit but vulnerable to losses if the programs are given up, and that deadweight losses occur as farmers use resources trying to capture program rents. He goes further to note that government's activities may be destabilizing rather than stabilizing, and that frequently there will be undesired and unintended secondary effects on the economy.

Pasour's paper grows out of a policy framework that is familiar to economists: welfare for a given pattern of resource ownership can be maximized by market activity where competition exists. In some but not all cases, imperfect government can improve on imperfect markets; and when undertaken, the direction and costs of income redistribution should be known. Rather than repeat his analysis, I will turn to the question of the generation of policy. I will argue that policy can be understood and analyzed objectively by the application of familiar concepts.

The economics of public choice (Buchanan and Tullock, Mitchell) consists of an application of marginal costs and marginal returns concepts to three levels of the public decision process: voting, legislation, and administration. I will discuss the three processes separately and then apply them to current policy issues, first emphasizing producer commodity policies; next, consumer commodity policies; and last, externalities and input policies.

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The Cost and Return Framework of Public Policy

In a representative system voters choose legislators and the executive officer based on their perception of costs and returns. Costs in this system include informing oneself of the positions of the candidates, travel to the polls, and possibly contributions of time and money to campaigns. As in other maximizing behavior, marginal cost will equal estimated marginal return at equilibrium. This leads some citizens to contribute large sums of money and others not to bother to inform themselves and vote. In terms of commodity programs, producers' benefits are more concentrated than are consumers' losses, leading to greater influence of producers on policies than their numbers would justify.

The legislative process also can be analyzed in terms of costs and benefits. A legislator will assess the benefit he hopes to receive in terms of reelection votes and funds from his vote for or against a bill. This assessment is complicated by the fact that votes are traded among congressmen, and a system of grants of power is operated inside the legislature based on past participation in the exchange system. These grants of power included creation of a set of committees each with its own purview, determination of committee membership and officers, and development of operating rules for passing legislation. At any one point in time, power is distributed among congressmen and committees as a function of a previous set of transactions. Thus the structure of committees reflects past power as it affects the difficulty or ease of passing legislation. A committee that deals with consumer (food aid) and producer (commodity) interests and that reflects previous power may be able to reach compromises in committee that would be more difficult if left to less formal vote trading on the floor.

The cost of legislation is measured by the

expenditure of resources and the distribution among the citizenry. The perceived costs are a function of the means used to finance the activity. Until the 1860s, consumers of goods protected by import levies paid for national public services. Import levies are still used to pay for some agricultural price support operations. Another "low-profile means of financing a given transfer is output restriction. Here the consumer pays a higher price for the product than competition would entail, but the costs are hard for the voters to estimate. Still another is the budget deficit that imposes costs through future interest payments on debt and/or inflation.

The executive and the bureaucracy make up the third level of the cost-and-returns analysis. The executive bargains with the legislature by making and withholding appointments as well as through the veto. The president and his cabinet officers may ask for and receive discretionary power over quotas and price supports. While this issue is usually justified in terms of flexibility, discretionary authority is a means of shifting power between the legislator and the executive, and in the long run affects the costs and returns to legislation.

A particular bureau can be thought of as a monopolist supplier of its own specialized services (Niskanen). Sometimes the executive acts to create competition by creating new bureaus and sometimes he tries to appropriate the value of the monopoly to his own reelection through the power to appoint officials. Once created, bureaus take on a life of their own including the drive to survive.

Analysis of Current and Future Policies

Following a series of attempts to restrain production to raise prices and transfer income outside of the U.S. Treasury, the major field crops (cotton, wheat, feed grains) have been "deregulated." Historic acreage allotments have been abandoned (Spitze). Loan rates now provide insurance against low prices, and target prices are employed to determine the level and distribution of direct payments. The most important forces that led to this "market orientation," as it has been called, were (*a*) the gross receipts foregone from high product prices in an era of increasing export demand and (*b*) the costs of developing and maintaining restrictions on production. The pull of world prices influenced the development and gradual increase in direct payments for feed grain crops (1962 forward), producer rejection of marketing quotas for wheat (1964), and use of export subsidies and direct payments for cotton (mid 1960s). Good times allowed direct payments to be discontinued. Speaking loosely, producers freed themselves from restrictions they had chosen earlier.

The major current and future policy question for these crops if export demand declines is the choice between diversion and high market prices versus direct payments to augment farmers' incomes. Producers will favor higher market prices; exporters and consumers, direct payments. Present arrangements do not distort resource use greatly but they clearly favor wheat producers (Johnson), probably explainable by the concentration of the economic importance of wheat in a number of relatively rural states.

Rice and peanut programs have moved toward greater "market orientation," substantially because of the high treasury costs of earlier programs. Rice programs now resemble those for wheat. The peanut program allows the Secretary power to set quotas and two levels of price supports which are lower in parity terms than those mandated earlier (Stucker and Boehm). A surge in demand has led to unexpected increases in exports and left quota holders with about the same benefits as earlier. If program costs stay down, there probably will be little consumer force to further reduce production restrictions. Rivalry among producing regions can be expected to grow if technology continues to affect the regions unequally, perhaps eventually leading to production realignment, as in cotton.

Tobacco is an interesting public choice case. It is rigidly controlled by quotas and price supports, and there is no move toward deregulation. This is the case because consumers have acquiesed in a sumptuary tax equal to about fourfold the farm cost of production (Gardner). Quota owners collect only about 1/15 of this tax. The only future forces leading to reduced control are a possible increase in the elasticity of demand as tastes and technology change, and possibly a divergence of interest among the producing regions and between operators and quota owners.

Policy making for sugar represents a microcosm of agriculture and food policy generally. Consumer prices, producer benefits, protection of refiners, minimum wages, and trade are all involved when new legislation is sought. As

things stand, sugar is subject to less regulation than it has been in decades. Should world prices fall sharply, there will be considerable pressure to reinstitute support prices and direct payments for producers. The current agreement between the administration and Congress is to use tariffs and duties to maintain a U.S. market price of 15.5¢ per pound (*Congressional Quarterly*). As noted earlier, consumers have a reason to press for world prices, perhaps adding direct payments which are paid for by taxpayers and are highly visible. Fewer than 21,000 producer firms are directly affected, but the extent of the loss in revenue per firm could be great, particularly among the larger cane producers. Although smaller in size, beet producers are distributed across a number of western states. The leader in the Senate for producer-oriented sugar policy in the past several years has been Senator Church of Idaho, who is up for reelection this fall.

Classified pricing for Grade A milk has been a part of federal policy for over forty years, after coming into being informally in the 1920s (Buxton). The demand side of the market is the acknowledged focus of the law. This is a sign to most economists that income is being transferred. Most of the transfers taking place under the program are between consumers of manufactured products and consumers of fluid milk. Grade A producers have benefited at the expense of Grade B producers, causing a wholesale upgrading of production. Despite the changes in the structure of the dairy industry, it is probably true that Grade A producers are now receiving substantial rents (Dahlgran). These rents largely have been dissipated through high cost production in response to blend prices and unlimited entry.

Consumers, politically less effective than their numbers of aggregate losses represent, currently are seeking the aid of the courts. The Consumer Nutrition Institute is party to a suit to force a federal order area to allow reconstitution. A fluid product consisting of half fresh milk and half reconstituted milk would lower the price of the product, in essence breaking the classification structure. This is the reason reconstitution has been prohibited or taxed out of existence (Buxton). Even if it is allowed, it is not clear that it will cause a lowering of the fluid milk price in all federal and state order areas. This could lead to pressure to rewrite the legislation.

Price supports (1949) and import quotas (1951) grew out of the side effects of the "surplus" generated by classified pricing. The relationship between quotas and price supports continues. If quotas are increased, price supports will have to be lowered if government stocks are to be kept low. EEC dairymen have not been able to offer greater demand for U.S. agricultural products in exchange for increased U.S. imports of dairy products. Thus it may be some time before these policies are changed significantly.

Food Subsidization

The traditional policy has been to tie income transfers to goods. In the major program, food stamps, the ties have been loosened gradually and are now nearly gone. With the removal of the purchase requirement, food stamps have become an income transfer program. The old arguments to maintain the program in the USDA and under the congressional responsibility of the agricultural committees have less and less force. A further shift from commodities to cash in the other nutrition programs would also contribute to a jurisdictional dispute between the USDA and HHS. If there is a realignment of bureaucratic and congressional responsibilities, there probably will be a decline in the power of agricultural interests because under the present regime important compromises between the welfare lobby and the commodity lobbies are made inside the committee and floor debate is minimized.

Domestic Reserves and Restraints on Trade

The private market can and does provide reserves. Even so there has been pressure to develop publicly held reserves. Producers and the trade have resisted the creation of publicly held reserves in the recent past. In a third attempt in conjunction with the Russian trade suspension and producers fearful of market price declines, the administration has been successful. Aside from a number of other issues and arguments, I believe producers are correct in fearing the government-held reserves may be used to keep price increases from occurring in a period of short supply through the use of subsidized storage. As a focal point of consumer interests, storage beyond the level justified by costs and returns could lead to other restraints on trade. It was

the trade interruptions of the 1970s (Johnson) that led to the 1977 provision tying embargoes to high price supports in an attempt to restrain the administration from responding to consumer pressures to restrict trade. It is likely that the consumer-producer conflict on trade will be one of the important policy issues in the years ahead. Consumer-oriented trade restrictions to the detriment of producers is common abroad (Perrin and Scobie). Perhaps producers' best defense in this country would be a doctrinaire embrace of free trade.

Energy

In extending the favorable federal gas taxation of gasohol to 1992, the windfall profits legislation has also potentially affected agricultural policy. This is an instance in which consumers concerned about energy (commodity) prices and farmers joined forces to increase the demand for a farm product. A 4¢ advantage at the pump for gasohol becomes 40¢ at the ethanol distillery. State gas tax rebates and favorable federal income tax treatment raise the subsidy to over $1.00 in some states (Sanderson). At 2.5 gallons of ethanol per bushel of corn, this translates to a subsidy of $2.50 per bushel of corn. Depending on the efficiency of ethanol production and the real price of petroleum, the price of corn could be increased significantly by the current subsidies. Thus energy policy becomes agricultural policy, at least partially inadvertently.

Other Policy Concerns

While commodity policies dominate public policy there are other important issues: food purity, the environment, and worker safety. The current wave of concern grew out of externalities associated with new chemicals used in production whose side effects began to emerge in the 1960s. While the "public interest" movements can be explained, it is not easy to predict their future power. Having generated a new kind of consumer organization and several powerful bureaucracies (EPA, OSHA, and an expanded FDA), they could remain forceful for some time. Using cost and return factors, I would suggest that the force of the movement will recede as more is known about externalities, the costs and benefits of present procedures are widely understood, and as other policy issues command the attention of consumers. I would expect interest in product purity to persist to a greater degree than with the environment and the safety of farm workers.

Farm input policies have evolved and probably will change slowly in response to new forces. One area of active policy making concerning inputs is the substitution of subsidized crop insurance for an open-handed disaster payments program. This is a contest between farmers and the ASCS who favor the current program, and the FCIC and taxpayers, represented by the administration, who favor insurance. In a similar contest between bureaus, grant research is threatening to reduce the importance of formula funding. In these two contests consumers probably perceive they have little to gain or lose and will be inactive. Producers may be enlisted to support formula funding if they become persuaded that their product or state is threatened by grant funding.

There has been a great deal of attention to "structure" in the past several years. It is possible that it will emerge as an issue in the 1980s but I do not see producer, consumer, or taxpayer interests strongly at stake. "Structure" can refer to some measure of the size distribution of firms, the contractual relationships among input owners (usually called the "control of farming"), and probably to other factors. The current organization of farms may have been affected by previous policies such as price supports, disaster payments (USDA, U.S. G.A.O.), and the general responsiveness of the political system to farmer interests. Even so, the concept of structure is currently so ill-defined that it is ripe to be used as a facade for bureaucratic interest or producer justification for free insurance, income transfers, or some similar program.

Some Concluding Comments

There is a pattern in the policy episodes of the past that we can expect to see in the future. Initially an economic shock occurs that imposes sufficient costs for those affected to expend resources to try to achieve some political action. If legislation is successful, unintended effects and costs gradually show up. Then as these costs mount or as economic conditions improve, the policy is altered to be less restrictive on market forces. After the problem is

substantially "solved," a bureau remains, seeking a new policy to supervise. Even so the major agricultural policies have not prevented the working out of economic forces. They have prolonged the adjustment process and in the case of commodity programs have transferred sizeable amounts of income and resulted in significant resource waste. But thus far they have not frozen the entire sector in an antiquated pattern. To be sure, some policies have had long-run impacts on agriculture—good and bad—and some are now more restrictive than are consistent with societal objectives. Hence there are pressures to change them. This does not argue that policy is an unimportant field of analysis. It is, instead, an argument that the analysis of public choice is more complex than private choice, political exchange more difficult to predict than market exchange.

In the area of public choice, prices and quantities are not available as instruments of analysis. Costs and returns concepts are used less frequently. Consequently some issues are likely to be emphasized more than careful analysis will justify. In the current situation, I would judge the attention given to structure to be relatively misplaced. As another example, I see almost no reason to debate the merits of parity versus cost of production. It is the level of support relative to market prices that counts.

Agricultural economists have a great deal to contribute to the analysis of public policy if they will apply their conventional tools to this unconventional area as objectively and vigorously as they have to market questions. If they fail to do so because of their proximity to producer interests, they will forego an interesting and important area of endeavor that other economists will pursue.

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Reconciling Agricultural Pricing, Environmental, Conservation, Energy, and Structural Concerns: Discussion

Allen Grommet

Some day agriculture price and income policy makers may consider the alternating conflicting and complimentary goals of environmental, conservation, energy, and structural concerns, but not in 1981. While I believe that land policy will be the subject of much future debate in agriculture policy forums, that time has not arrived. I do not believe that the quadrennial review of major farm legislation occurring in 1981 will change legislation significantly from the 1977 bill. I suspect the debate will be mostly on loan rates and target prices, with a continuation of the grain reserve rather than addressing the broader context of land policy discussed by Martin.

The comments here are not intended to represent those of the Congress, the House Budget Committee, or its staff on which I work. Instead, these remarks are personal reflections on likely agriculture legislative issues as a student of the policymaking process.

Martin has found the common denominator that could be used to reconcile many of the conflicting issues facing the broadly defined agricultural community. Even in the 1930s, farmers realized that when price and income policies could not be sustained under the Constitution on their own, certain supply-controlling policies under the pseudonym of conservation could be used to obtain the same ends. Politically, the policy issues may evolve in another decade or so where land policy may once again be the central focus of agricultural policy. In order to continue to receive the benefits of price and income policies, farmers may well have to form coalitions with environmental, conservation, energy, and other groups. The common factor that bonds these groups may be policies affecting land. And certainly any policies affecting land will have an effect on farm structure. While I agree with the technical possibilities of reconciling these issues through land policy, I believe there are strong institutional encumbrances stalling this eventuality at the national level.

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Interest Group Dynamics

If all of the issues affecting agriculture are going to be reconciled, there must be a constituency interested enough in each issue to push for legislative changes. Currently that constituency does not exist for some of these issues when farm income and prices are discussed. Environmental, conservation, energy (except biomass in the 1977 farm bill), and other interests tend to be "one-interest" interest groups that shy away from omnibus legislation. Most farm organizations as well do not want to compromise income and price policies with other concerns. Without an interest group participating in the agriculture policy debate that is willing to bargain and trade influence on the public decision process in order to obtain concessions from traditional farm groups, the agriculture price and income interests simply will not introduce the additional issues into the debate.

Land policy issues such as conservation, environment, and energy are earnestly debated by such groups as the National Wildlife Federation, the Sierra Club, and others that have never been involved in influencing agriculture legislation. Until these groups are ready to show their concern about how these issues should be considered within the context of farm income and price debates, no reconciliation will occur. In fact, at the present time these environmental groups are not even recognized as legitimate participants in the farm income and price debate. Legitimacy could be achieved in time with direct testimony to the agriculture committees and overtures not only

to the Department of the Interior but also to the Department of Agriculture. Further legitimacy could be obtained by developing a block of congressmen and senators who are willing to put their names on the line in the agriculture income and price debate as being equally if not more concerned about environmental and conservation matters than about farm income and prices. Until that happens, policy making in the Congress will not force a reconciliation of these issues.

Lack of a Forum for Reconciling Conflicting Land Policy Issues

Not only are there no interest groups working to reconcile these conflicting issues, but the institutional structure of the federal government generally prevents reconciling these issues. Jurisdictions and responsibilities are so split and delineated that they prevent reconciliation of these policy issues until they reach the highest levels of government, and often the differences in the issues are not significant enough when compared to other national issues to warrant the attention of the president, the White House staff, or congressional leadership.

If the Department of Agriculture were going to play a leadership role in reconciling the conflicting issues involving agriculture, they would have to work with a long list of other agencies and departments. For instance, the Environmental Protection Agency plays a leading role in environmental issues affecting farm chemical usage and nonpoint source pollution, such as soil erosion. The Department of Energy plays a lead role in developing fuel and energy alternatives such as gasohol. The Food and Drug Administration is involved in food regulation. Structural problems such as the development of farm coops have been handled by the Department of Justice. International trade issues involve the Departments of Commerce and Treasury as well as the Office of Special Trade Representative and the International Trade Commission. As a consequence of these and other possible examples, it is difficult to see that the many conflicting agricultural issues can be resolved or reconciled even at the cabinet secretary level without involving an "arbitrator" with authority over a number of departments.

If we look at the Congress, similar jurisdictional disputes occur. The Agriculture Committee handles the price and income policy; however, the Science and Technology Committee in the House is the major forum for discussing all research programs including some agriculture research. The International Affairs Committee handles major matters on trade. The Public Works Committee reports bills affecting transportation issues. The Ways and Means Committee handles all the tax legislation that has significant influence on the structure of farming. The Small Business Committee is involved in loan policy affecting the structure of farming and other small businesses. The Labor and Education Committee in the House reports legislation on the human nutrition programs. And if that separation of jurisdiction is not enough, the Appropriations Committee is split into thirteen different appropriations subcommittees where spending authority is further separated.

Even the budget process does not force a reconciliation of these issues in the agricultural sector. The budget forces many trade-offs among competing parts of the economy, but on a much broader base than the agricultural sector. Energy is treated in the context of all energy programs; conservation is treated in the context of other natural resource programs. The agricultural function in the budget deals only with the farm support programs, service, and research programs. The programs in the Department of Agriculture fall into some seven different functions of the nineteen in the federal budget.

More Research Needed on Institutional Developments

The biggest problems in reconciling the broad content of agricultural issues (including land policy) are the institutional limitations. Further economic research on these issues is important, but one should not look to the legislative or executive decision process to reconcile the policy differences on these issues any time in the near future.

The piecemeal approach attempting to solve each of these different policy issues, while not necessarily the most efficient method, may still make improvements, but a coherent policy among all of these issues must await further institutional developments.

The Farmer-Owned Reserve: How Is the Experiment Working?: Discussion

W. Scott Steele

The paper written by Meyers and Ryan does a good job reviewing the background and operation of the farmer-owned reserve program. They also have developed a model to analyze the market impact of the reserve. Their results indicate that without the reserve we would have seen lower average prices and higher price variability. Finally, the authors raise a number of relevant issues about operational problems as well as the future prospects for the reserve as a policy instrument.

I would like to elaborate on their paper, giving my impression of how well the reserve has worked and what needs to be done to keep the reserve operating effectively in the interest of both producers and consumers.

The Meyers-Ryan paper correctly points out that raising the storage rate and allowing immediate entry of 1976 and 1977 crop wheat into the reserve were important factors in increasing the rate of accumulation after a slow start. Nevertheless, producers had substantial incentives to enter the reserve during the accumulation phase. The release level was higher than farm prices during 1977 and 1978. But, with the target price set above the release level for the 1978 and 1979 crops, producers had a reasonable expectation that farm prices would come up to or near the release level. Because the producer had to recover only about 14¢ more than the prevailing farm price (6% interest for the first year of the reserve loan) to break even, the potential benefit of entering the reserve outweighed the cost.

Prices increased during May 1979 and triggered release of the wheat reserve. Removal proceeded in an orderly manner over the release period. This was contrary to the expectations of some who believed farmers would dump reserve grain on the market.

The situation for corn was similar to that of wheat. Farm prices in many areas were below the loan rate. Producers had substantial incentives to enter the reserve during the accumulation phase. The release level was higher than the farm price during 1977 and part of 1978. The producer had to make only 12¢ per bushel more than the prevailing price to break even.

As with wheat, the opportunity for farmers to enter corn immediately into the reserve greatly accelerated the rate of accumulation. In June through August, corn was in release status and, like wheat, removal of the corn reserve took place in an orderly manner.

The initial phase of the wheat and corn reserves went smoothly. The incentives were there to gain the participation of farmers. As I indicated, the key to participation was the relationship between the farm price, the loan rate, and the release level. Farmers had a reasonable expectation that the release level would be achieved. A higher release might have been attractive because the potential gain would have been larger. However, if producers did not have an expectation that the release level would have been achieved over the three-year reserve contract, they may have been reluctant to enter grain in the reserve.

Although the wheat and corn reserves performed effectively, the barley reserve did not. The problem was that the price series that was used to trigger release and call of barley was a national all-barley price series. As a result of higher prices on the West Coast, where less than 10% of the reserve was located, and because of the influence of malting barley, which usually commands a premium over feed barley, the barley reserve was placed in call status beginning 26 June 1979. However, farm prices in most of the Northern Plains, where the reserve was held, never rose above the release level.

Several changes in reserve operating procedures were necessary. Because the release and call levels are based on the barley loan level, and because the barley loan is tied to the

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corn loan on a feed value basis, it did not seem appropriate to use a barley price series that included malting barley. It was decided that a feed barley price series should be used. Second, because the West Coast barley market greatly influenced release and call of the reserve and West Coast producers participated only marginally in the reserve, it seemed appropriate to use a feed barley price series that was related to the location in which the reserve was held.

Changes in the operation of the reserve had been in the planning stages for several months prior to the Soviet suspension. However, in order to deal with the domestic impacts of the suspension, greater incentives were given to farmers to participate in the reserve program. Some adjustments in the reserve no doubt would have been made even without the suspension.

Periodic adjustments in the reserve program are needed so that it remains attractive to producers. Participation in the program is needed if there is to be sufficient grain in reserve to meet shortage situations. The adjustments in the reserve that need to be focused on are the loan rate and the release and call levels.

The loan level is important because that is the "price" the farmer receives for going into the reserve. Unless farmers can be assured of sufficient operating capital to meet their cash flow needs through these loans, they will be reluctant to commit substantial quantities of grain to the reserve. The loan level can be adjusted to make the reserve entry more attractive. In this regard, the administration recently raised wheat and corn loans which, in turn, raised release and call levels. Moreover, it should be noted that Congress is now working on new legislation, which is supported by the administration, to provide authority for a special loan for reserve grain. This special loan would provide for a supplemental payment over and above the general loan and would give a further incentive for program participation. The release and call levels still would be set in relation to the general loan and would be unaffected by this legislation.

As mentioned, the release and call levels are also major determinants for the effectiveness of the reserve. To attract any significant quantity of grain, the release level must be high enough to cover the current price plus any additional costs incurred by the producer from entering the reserve.

Another consideration in setting the release level is the target price. In order to reduce budget exposure, the release level should be set above the target price. Otherwise, the operation of the reserve could force additional outlays for deficiency payments.

Finally, the release and call levels need to be adjusted in order to provide the opportunity for adequate returns to producers in the face of rising costs. If the operation of the reserve does not permit farm prices to cover costs and provide a profit from time to time, then the reserve would be placing the farmer in a disadvantageous economic situation. During the current year, we have seen costs of production increase dramatically. The July adjustments in loan rates and release and call levels will provide greater flexibility for market prices to match these cost of production increases. Further adjustments in the reserve for the 1981 crops are now under review. In making adjustments in reserve operating rules to compensate for increasing production costs, Meyers and Ryan remind us of the potential problems of using the reserve to support prices above world market equilibrium levels.

If adjustments in release and call levels are made periodically, keeping in mind the considerations I have mentioned, then the reserve should be viable over the long term. Farmers should continue to participate in the reserve and by doing so, will ensure themselves higher returns as well as provide consumers greater assurance against severe price increases.

Based on our experience so far, we generally can conclude that the economic situation of farmers is better with the reserve than without it. The other side of the coin is the benefit to taxpayers and consumers. They incurred costs as the reserve was accumulated and only benefit when it is released. When the farmer-owned reserve has been in release, we have seen an orderly withdrawal of grain and the tendency for price increases to moderate. However, the reserve has not been tested in a really tight supply situation. That situation may well be on its way, given the current outlook for 1980 U.S. feed grain production. Hopefully, the reserve will meet the test.

Changing Rural Data Needs
(W. E. Kibler, Economics and Statistics Service, Presiding)

Changing Rural Development Data Needs

James T. Bonnen and Glenn L. Nelson

Rural America is changing. It is changing more rapidly and in more fundamental ways now than perhaps it has since farming displaced hunting and fishing. Entirely new questions about the nature of these changes and the future of rural life are being raised. Answers are often difficult to obtain.

We have long paid too little attention to the nonagricultural dimensions of rural society, allocating few research resources and paying inadequate mind to the policy needs of rural society. Farmers and their families now constitute only 13% of the rural population (U.S. Dep. of Commerce). The migration of millions from farming has come to an end, leaving a very different rural society behind—one in which farmers are a minority, and agriculture provides employment for only 10% of the rural work force (Deavers and Brown).

Rural America is now in a rapid transition toward a new and very different society. The tide of migration has turned back toward rural areas, where population is now growing more rapidly than in the cities (Beale, Beale and Fuguitt, Morrison and Wheeler). Rural communities have become so heterogenous in social and economic character that, not only can most no longer be described as just farming communities, but it is often difficult to describe them accurately at all from the current data base. Of the approximately 39,000 local units of government in the United States today, more than half have populations of 1,000 or less, 70% have less than 2,500 (U.S. Dep. of Commerce). These communities have limited capacity to develop their own data bases. Census of population and housing data on the social and economic conditions of rural people and their communities, while generally the best we have, are available only once every decade and for these smaller communities are neither very comprehensive nor reliable.

Because the nature of rural society is changing rapidly and the rural population now appears to be the fastest growing sector of the U.S. population, the lack of ability to understand that change and to provide coherent policy direction can have costly consequences. Rural America is not just a residual left behind by the urbanization and industrialization of the United States. It is more than a fourth of all Americans, and it is a diverse and growing sector of the economy whose problems are an important part of the decentralization of national economic activity and population now taking place. Effective public and private policy requires an appropriate rural data base. But there is no consensus on what constitutes such a data base.

It is the conclusion of this paper that the inadequacies of the rural data base are part of a complex problem of circular causation. There is widespread agreement that the data base is deficient but little consensus on what constitutes the most important deficiencies. The question of what needs to be done does not elicit a coherent answer.

The lack of coherence that characterizes the current data base is due to a lack of coherence in rural development policy itself. The specification of data needs and design always arise out of use. This policy area has long been characterized by a slowly growing collection of specific programs. Collectively, however, they do not amount to a coherent policy and do not imply an integrated view of present

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rural problems or of the future of rural society. Why?

Short-run explanations tend to focus on the fact that the programs serve different clientele and are managed by a large number of different agencies, accountable through various lines of authority, scattered over several cabinet departments.[1] In the long run, these obstacles would not be insurmountable if we, as a society, had an intellectually coherent, widely accepted, prescriptive vision of the future of rural society, and some sense of the obstacles to that vision. In fact we do not.

Our inability to develop any clear prescriptive vision of that future arises from two primary sources. One is a long-time failure to recognize and resolve the broad value conflicts implicit in the different views various groups hold about development issues: the growth of government services, tax equity, land and water development and use, centralization versus local self-determination in governmental services and organization, and others.

The other source of this failure to evolve a coherent vision of the future arises from the deficiencies of the data base itself. The extensive nature of the changes in rural society and the speed with which many of these changes have come have left us with a poor descriptive and conceptual understanding of the current state of rural society. In fact, we still cannot define clearly what the concept "rural development" means (Daft 1978). Thus, the circularity of the problem arises ultimately out of the interdependence in policy decision between positive and normative knowledge as well as the inherent epistemological dependence of conceptual (deductive) knowledge on empiric (inductive), and vice versa (Bonnen 1975, 1977).

Even if one sets out only to describe the deficiencies in the data base and their origins, one is led eventually into this circular train of causation. The problems of the rural data base are most clearly understood when seen as an information system failure. Thus, we will devote our efforts here to an evaluation of rural development policy as an evolving information system. A data base can only be defined and fully understood as part of a larger decision system.

[1] Bryant has an excellent analysis of the lack of coherence expressed in terms of the fragmentation of the demand for rural economic and social statistics and the dominance of the supply side by a few federal agencies with little bureaucratic interest in rural people.

In this paper we shall briefly examine the historical evolution of development policy and follow it with an assessment of the current state of rural society. Then, we will evaluate the implications of all this for rural development data needs. Finally, we report briefly on a National Academy of Sciences panel which is addressing the problems of "Statistics for Rural Development Policy."

The Evolution of Rural Development Policy

American citizens have been guided in their lives by a system of values which has remained quite stable. John Brewster identified several closely related sets of values in an examination of nineteenth century America (see especially pp. 14–28 and 60–61); this configuration of values has remained a dominant influence in rural life. Democratic values include the ideals of equality, self-determination, and representative democracy. Work values attest to the worth of work, the importance of equal opportunity in preparing for and finding work (distributive justice), and the commutative justice of a fair return. Enterprise values include the beliefs that success in private enterpreneurship is a proper test of a person's worth to society and that the competitive striving of entrepreneurs yields the most good for all, including sufficient jobs for all who wish to work.

Facts, i.e., our understanding of reality, have been considerably more volatile than values. Individuals and the institutions of society are continually buffeted by new situations, especially changes in technology and knowledge, that render obsolete previous beliefs about the facts of their situation. In turn, problem definitions, which reflect the difference between "what is" (beliefs about facts and values) and "what should be" (prescriptive beliefs), will change, with public policies then modified to address better the redefined problems.

Over long periods of time one observes changes, not only in beliefs about facts, but in values and prescriptive beliefs. These changes are interactive or dynamic. The rest of this section summarizes the results of a historical analysis of rural development policy. Shifts over time in policy are interpreted in terms of perceived imbalances between changing beliefs about "what is" and "what ought to be" in rural life. It is this perception of imbalance

which powers and limits what is possible in the policy process.

Cochrane's recent volume on the economic history of U.S. agriculture provides an especially useful historical starting point for this analysis. We are also dependent on the rural development literature including that from rural sociology. The interpretation and framework are entirely the responsibility of the authors. We started in the mid-nineteenth century and examined the changing perceptions of rural society, its values, problems, and related policy responses. Our conclusions are necessarily composed of generalizations about quite complex matters.

In the mid-nineteenth century, the traditional value system of rural America outlined above provided clear, rather stable role images at work and in the family and a strong faith in nature and natural processes. Rural communities were generally isolated, self-sufficient farming and mining or lumbering communities which, compared to today, were each relatively homogenous in values. The frontier was perceived as offering an equal opportunity to all, though hard work was expected. Enterprise beliefs were strongly held and viewed as an important cause of American success. The appropriate role for government was limited to the provision of services which people needed to become established and to prosper as proprietors.

Up until the 1950s, agricultural policy and rural policy were viewed as synonymous. National policy responses designed primarily to affect rural welfare focused on farmers as proprietors. Such policy actions in the nineteenth century facilitated farmer access to land through homestead legislation, subsidized development of a transportation network to deliver inputs and market outputs, and attempted to assure equal social and economic opportunity for farmers through land grants for public education. These policy actions supported greater attainment of democratic, work, and enterprise values with little need for trade-offs between values. Twentieth century rural policy can be characterized primarily as responses to perceived market failure; the earliest legislation on farm credit passed in 1916, land reclamation and irrigation in 1902, soil conservation in 1933, and commodity price supports in 1929 and 1933. Though focused on consumer as well as farmer welfare, growing economic concentration and monopoly led to the first antitrust legislation in 1890; abuses by food marketing firms resulted in regulatory legislation (1906 and 1921) setting standards for food safety and controling meat packing and stockyard practices.

Thus, the twentieth century saw a very different pattern in rural value attainment and policy. Technological, social, and economic change created market failures and concentrations of power which impaired democratic values of equality and self-determination, as well as the equal economic opportunity and fair return values of the work ethic. The Great Depression of the 1930s was a watershed in social policy, which shattered the belief that a freely competitive system would produce prosperity and jobs for all who wished to work. The policy response was to trade a substantial impairment in enterprise freedom for greater attainment of democratic and work values.

Following World War II, the perception of rural society began to change. The exodus from agriculture reached unprecedented rates in the 1950s and 1960s as a major technological transformation occurred. Slower national economic growth over the last half of the 1950s led to a back-up of underemployed labor in rural areas. Rural incomes lagged significantly behind urban, and again rural people faced a growing mismatch between actual conditions and their work values. While the major policy response was still in terms of farm programs, for the first time a growing realization that agriculture and rural could no longer be regarded as synonymous led to new policy initiatives.

The community self-help programs of the 1950s and early 1960s reflect an uneasy tension among values related to equity, enterprise freedom, and community self-determination. The Rural Development Program of 1955, the expansion of Farmers Home Administration programs to rural housing, water, and sewer needs, and the Rural Areas Development program of 1961 were intended to aid rural communities in organizing to solve local problems. In actual fact, the programs were modest and had little impact. They did recognize, however, for the first time that revitalizing rural areas required more than just farm programs.

In the 1960s and 1970s, small business loans, housing, public facilities, and development planning programs for small communities were created in several agencies outside the Department of Agriculture (USDA).

The Rural Development Act of 1972 brought together in one place, and expanded substantially the authorizations for, many rural development programs. However, the emphasis remained, as it has since the 1950s, on programs not policy, on community self-determination, and on the welfare of places not people (Daft 1972). The Carter administration announced its Small Community and Rural Development Policy in late 1979. This involves no significant shifts in programs or value trade-offs.

But the larger society was in ferment. The mid-1960s through the 1970s saw an explosion of government activity in response to increasing dissatisfaction with the attainment of democratic and equal opportunity (distributive justice) values. The rights of minorities to participate fully in the nation's political, social, and economic life were strengthened. Consumer and worker health and safety as well as environmental protection became major issues. Many of these policy initiatives further restricted enterprise freedom in order to enhance the democratic value of controling one's own destiny and the work values of equal opportunity and fair play. While new programs were directed specifically at depressed rural areas, this period is better characterized as one in which rural areas were swept along in a new wave of national policies, than as a period of new rural policy creation.

Current State of Rural Society

Rural institutions have evolved through the interplay of new factual knowledge and shifting priorities among values. This is a continuing process. Technological and social changes are occurring at a more rapid pace in nonmetropolitan America than perhaps any time in history. Changes in "what is" show signs of outpacing the capacity of institutions to establish and achieve society's beliefs about "what should be." We sketch below the current state of some of the major dimensions of rural society.

While the enthusiasm for science and technology has been dampened by nuclear accidents and chemical residues in the natural environment, they remain powerful forces for change. Since World War II, technological innovations in transportation and communication have made possible a decentralization of production and distribution with centralized control. This has permitted the steady growth of manufacturing and service employment in rural areas over the last three decades. Even the headquarters of some firms are now locating in rural environs that have convenient access to a major airport. Thus, the centralization of control no longer necessitates the kind of spatial concentration of economic activity which characterized the first hundred and fifty years of the industrial revolution and powered the growth of metropolitan areas. We have reached the end of a long era of increasing population concentration.

The return migration and a rural population now growing more rapidly than metropolitan are the product of extremely complex forces which we have only begun to understand. The slow decentralization of economic activity and employment is only part of it. Extensive interstate highways now allow more people to commute to work over longer distances. The earlier migration to the city for jobs is now leading to a return for retirement. Second homes for recreation become retirement homes. Development of new energy sources has created boom towns and large rural electrical power generation sites in Western coal areas. Americans have long had a preference for rural residence (Zuiches and Fuguitt). Only in the last few decades have economic opportunities and higher levels of living enabled them to act on their preferences for rural amenities.

Urban mass culture began to influence rural values, self-perceptions, and world view as soon as the isolation of rural life started dissolving in the revolution of transportation and communication technologies. The growing involvement of rural people in industrial and urban vocations, in higher levels of education, in use of the mass media, and in greater spatial mobility leads to a general convergence of rural values and beliefs with those of urban life. Though many differences remain and even grow, rural and urban life are slowly moving toward each other in many beliefs, in material levels and standards of living, even in desired amenities (Larson). This convergence likely will be accelerated by the return migrations.

We long ago reached the point where "there is no separately manipulatable rural society" (Daft 1972, p. 4). The integration of local rural markets and social organization into the evolving urban social order makes it impossible to construct a rural development policy with a

unique geographic basis distinct from urban. Too many economic and social structures and problems are common, and most are regional or national in scope.

On the other hand, there are also great differences between rural and larger urban communities. Unique to rural society are the diseconomies arising from the greater space over which all organizations and functions must operate and the very different mix of resources, enterprises, vocations, and amenities which still characterize rural communities. So, some problems are quite different. Policy and legislation addressed to such diversity will itself be inherently diverse. An omnibus rural development policy is an impossibility. In some cases, the unique aspects of rural communities and their needs can be recognized in designing national policies. In others the problems may be so uniquely rural, separate programs and policy are needed. Even these are likely to be scattered over several executive departments and congressional committees.

As rural life has been integrated into an urban society, its economy and vocations have grown far more diverse. Self-sufficiency, isolation, and local organization have slowly given way to regional specialization and to a system of mostly national level economic and social institutions. This newer, evolving social order has increased productivity. But its specialized institutions have also increased the dependence of individuals, organizations, and communities one on another and reduced the local community's capacity for problem solving. Resolving local community problems requires cooperation between and integration of the activities of many of these same specialized, nationally directed systems. This is difficult because they are often more inclined to bureaucratic warfare than to cooperation. This change leads toward a concentration of economic and social power which simultaneously undermines enterprise freedom as well as the real achievement of democratic values.

As society grows complex, technical, and bureaucratic, the individual becomes dependent on people, organizations, and forces he or she does not know or understand. The sense of self becomes depersonalized and problems with life are less frequently perceived as arising out of one's own personal limitations and are attributed to deficiencies of the society. This has major implications for the way norms and reality are interpreted and for what is seen as an appropriate policy response to a problem.

Rural society is more heterogenous and pluralistic. All the variants of nineteenth century rural as well as today's urban lifestyles and beliefs now coexist and contend through rural life. Pluralism undermines absolute value commitments of traditional societies and leads to relative standards. It weakens the individual's faith in any particular system of values and shifts one's perception of what is significant from the institutions of society, i.e., from one's environment to one's own unique subjective experience (Coughenour and Busch). Thus, as beliefs about values and objective reality share less of a common basis in experience, they become less stable and more fragmented. This undermines the social basis for policy and assures that future rural policy will be less stable and more contentious, from local levels to national.

The social and economic changes described earlier have transformed the structure and the role of government. Every level of government has acquired new functions, most regulatory in nature, and public subventions and services have grown immensely. Dependence has grown proportionately. In 1977, almost a fourth of state government receipts were federal monies, and almost 40% of local government receipts were state and federal monies (Dep. of Commerce, p. 289).

However, federalism with all its growth is in disarray, with no clear division of labor and an uncoordinated mixture of programs in which accountability and even purpose are often hopelessly confused. Responsibility for this chaos recently was laid at the door of Congress by the Advisory Commission on Intergovernmental Relations. The states, through the National Governors Conference and the National Conference of State Legislatures, are pressing hard for reform (*New York Times*).

While the authority of states has been progressively undermined by the federal government for decades, the states now are starting to assert themselves with some vigor. The other unit of government that appears to be in resurgence is that of the county. While the variation in nonmetropolitan America is extreme, those counties sharing in growth often exhibit a fiscal strength and management sophistication which local municipalities cannot match.

The ability of local government to deal with the current chaos in federal relations is quite

limited. They are frustrated and feel trapped between a rising tide of complex problems, their limited expertise and capacity, and a chaotic set of state and federal bureaucracies which intrude unilaterally and are quite uncoordinated and insensitive to local problems.

Public policy is the product of effective political power (Daft 1972, p. 4). The nonmetropolitan or rural counties, townships, and cities of the United States are not now effectively organized and represented in most states or at the national level. Farmers are organized but now constitute only a small minority of the rural population, and their economic interests are quite different. Until the rural units of government form an effective political coalition, there will be a political vacuum in rural America. Growing economic and social vitality and the return migration eventually should make this vacuum intolerable at the same time that it creates a potential political base of some consequence. But such does not now exist.

Implications for Rural Development Data Needs

The social value of rural development statistics is growing rapidly and will continue to do so for the forseeable future. Rapid change is introducing great uncertainty about matters of growing social significance—the future of rural society and a decentralizing social order. This, in turn, greatly increases the value of information necessary to deal with that uncertainty. We are entering a new era, the full implications of which are yet to be grasped. Until we understand it better, this transformation initially requires a major intellectual and research investment. The future contains many new elements and potential benefits and dangers. Our concern should be (*a*) that rural people understand what is happening to them, and (*b*) that intelligent policy direction be given to avoiding the dangers and to pursuing those potential opportunities that are responsive to the goals of local communities and of the society.

The growing uncertainty rural America faces is produced by important issues of increasing concern. One is the energy crisis. What impact will higher energy costs have on the return migration and the decentralization of economic activity which lies behind it? We will make many important public and private decisions in accommodating higher energy prices.

If the return flow of population and the rate of economic growth continue in nonmetropolitan America, clashes over land use and environmental issues can only grow more intense and more important. Similarly, the conflict over growth versus no growth, as well as the equity of various local community tax and expenditure policies under different growth philosophies, will grow.

The growth in government has unleashed a multitude of conflicts over modern federalism. What is the appropriate role and scope of government at federal, state, and local levels? How the other issues above are resolved will condition what roles and functions are finally focused at different levels in the federal system. Pressure to build greater capacity into local units of government will expand (Doherty).

As well as the accelerating intensity of specific growth issues, increasing complexity produces greater uncertainty and expands the intrinsic need for and value of information. The sources of this growing complexity include the fact that the distinction of rural versus urban is no longer a useful organizing principle. It is now too simple a concept to capture the varieties and conditions of community that exist today. Another complicating force is the greater centralized control of economic and social institutions now accompanied by decentralized activity. This implies a more complex capacity for coordination which not just the involved organizations but various information systems must sustain as well.

The increased heterogeneity and pluralism of rural society create a future with many more options than existed in the past. If these proliferating alternatives are not examined carefully at all levels in society, missed opportunities will grow and the probability of satisfactory outcomes will be reduced.

Fragmentation and increased relativism of values lead to a subjective self-image and world view. Consequently, an objective statistical base becomes an even more critical resource but also one more vulnerable to being politicized by subjectivity. Objective data do not necessarily add to stability without some consensus of related values. Achieving consensus where values are highly fragmented suggests the need for open public policy institutions and wide participation in reaching a

legitimate value consensus or at least a compromise that minimizes the political costs.

Both what is as well as what ought to be are at hazard in the decisions that will be made. The conflicts over values as well as fact need to be consciously addressed. The return migration and the imposition today of national trends on small communities are sure to fuel further conflict between enterprise values, equity, and democratic values. Federal government programs and regulation are already generating a severe conflict with the democratic value of self-determination expressed at the local level of government.

An adequate data base becomes more important as uncertainty is compounded by rapid rates of change and increasing complexity. Statistics cast many long and enduring shadows in policy and in the lives of people. The absence of appropriate data often casts even longer and more enduring shadows.

What kind of strategy for data development does this imply? To us, it suggests the necessity of an experimental or developmental strategy capable of discovering problem definition, decision information needs, the proper related concepts and analytical techniques, and the empirical needs for those decision purposes. In such a mode of inquiry there is no suggestion that one might succeed by addressing only one part of the system or that the entire information system could be built in a year or, in this case, even a decade. In reality, an information system is a process that never ends. The specifications for a data base develop out of the knowledge gained as the inquiry process, which supports a set of decisions, evolves. The difference is only the level of knowledge from which one starts and the rate at which that knowledge is made obsolete by change (Bonnen 1975).

We need also to realize that the idea of a singular coherent data base for rural development policy is a chimera—a Holy Grail never to be discovered. It cannot exist because there is not, and never is likely to be, a single comprehensive rural development policy. We can, however, address the data base problem in the context of specific policy decision areas, such as health, housing, land use, etc., where there is some necessary presumption, as well as possibility, of coherence in decision. Major problems arise, of course, when a decision involves trade-offs between these specific policy areas.

What can one say about the basic statistical problem? All statistics are labor-intensive, especially the collection process, and thus they have become more expensive in the United States. As one goes from large cities to the smallest, data of the same detail and accuracy require higher sampling rates and are even more expensive. Rural societal decisions increasingly require data in greater social and economic detail than are now available. These data also need now to be updated more often than they are. For many uses they need to be comparable to existing economic and social statistics for the United States. Thus the dilemma. Given the cost of data, how do we satisfy rural data needs without bankrupting U.S. state and local governments?

The value of data and their design criteria arises out of the uses of that data. The heterogenous nature of rural development policy and its information base requires extensive integration and coordination of decisions and information between many organizations and bureaucracies at every level of government. This implies a coherence in our federal structure that does not now exist. In fact, it is resisted stoutly by the public bureaucratic and private economic interests involved. Incoherence of the structure of decision ensures an incoherent data base—even for limited policy areas.

As a practical matter, what do we need to do to improve rural data? The first is experimental and research work. We need to understand rural society and the forces that are so rapidly changing it. We need to develop and improve the concepts, analysis, and measurement that inform that knowledge. Positive as well as normative knowledge is required for policy prescription. We must examine the implications of the alternative factual and value choices that lie before us. All levels of government should be experimenting, in search of better problem identification and means of solution. Statisticians need to work on statistical strategies and methods that can substitute for the more expensive conventional survey and census methods.

Federal and state levels of government clearly have major responsibilities to local government for the development of an adequate local data base. Many local data needs arise out of federal and state program requirements. Regulations and programs that create unnecessary problems and data de-

mands need to be revised. Federal, state, and local governments must cooperate in coordinating data needs among each other if an adequate common data base is ever to be developed without waste and duplication (Bonnen et al., 1980).

Conclusion

This paper has attempted to demonstrate several closely related matters. Rural development data deficiencies, with their circularity of causation, can be most clearly understood as information system failures. Second, what constitutes an improvement in specific data is completely conditioned by the purposes for which they are used and thus by the value structures and objective conditions of rural life that generate specific policy needs. Finally, rural development policy is, and will continue to be, a complex web of federal, state, and local activities, policies, and institutions, which to have coherence and a minimally adequate common set of data bases must, in some degree, be a coordinated system.

We have tried to define the nature of our persistent inability to specify "the" rural development data base and have put our emphasis on what tends frequently to be missed, the institutional information system and preconditions from which specific and coherent data needs are derived. This will disappoint those looking for specification of concrete data sets. That would require another article and, even then, would disappoint those seeking a statistical Holy Grail.

The authors' current perceptions of rural data problems arise from their participation in the Academy of Sciences Panel on "Statistics for Rural Development Policy." Academy regulations prohibit public discussion of panel recommendations before Academy publication. The Panel report undoubtedly will provide a more concrete specification of data needs and statistical strategies. That report should be available by early 1981. Because the Panel faces the same intellectual and institutional problems addressed by this paper, it is likely that their recommendations will focus on needed institutional change as well as specific data problems. We believe the Panel report, *Rural America in Passage: Statistics for Policy*, will be both useful and challenging.

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Some Concepts for Measuring the Economic Value of Rural Data

J. Bruce Bullock

Economists somewhat belatedly have begun to recognize and to understand the role of information in economic activity. The topic has received attention only since Stigler's seminal article on the economics of information was published in 1961. We have ignored the role of information in economic activity largely as a result of our almost exclusive use of theories and models based on the assumption of perfect information. Consequently, we have tended to assume away problems and complications caused by less-than-perfect information rather than to develop formal theories and/or models to deal with these issues.

Once we accept the fact that perfect information does not exist, one is hard pressed to arrive at measures by which to evaluate the performance and efficiency of various types of economic activity (Pasour and Bullock). Moreover, we begin to recognize that certain types of less-than-perfect information have economic value both to individual decision makers and to the public at large.

We have long realized and accepted the potentially positive contribution of publicly financed systems for the collection and distribution of various types of agricultural data. The usefulness and value of these data (information) systems have been taken more or less for granted. However, the increased public scrutiny of budget expenditures and the increased emphasis on program planning and budgeting as a tool of budget management has heightened our interest in determining the economic value of these systems and of proposed changes in the systems.

Our interest in public information systems has also been stimulated by other developments. The increase in the number of "thin" markets for agricultural products has raised numerous questions about the adequacy of our current price-reporting system. The continued trend toward fewer and larger farms and food-processing firms raises questions about the connection between industry structure and the nature of public information systems. These concerns suggest that the value of public data systems may be to monitor economic performance as well as to provide information for individual decision makers.

The purpose of this paper is to examine the current state of theoretical and methodological approaches to valuing information systems and to identify some of the problems and issues that confront efforts to determine the economic value of information systems.

Current Status

Eisgruber provided an accurate status report on the state of economic research relating to the value of information systems. "Neither theory nor methodology exist to address adequately the economics of information, and, until recently, little effort was made to overcome this deficiency . . . (p. 901). Later, he says, "the public as well as the private sectors spend considerable amounts of resources on the development and maintenance of information systems. Yet, as economists, we have, to date, provided little by way of assessing the effectiveness of these information systems" (p. 904).

Although a sizable body of literature dealing with the economics of information has developed in recent years, we have yet to develop an adequate theoretical or methodological framework for valuing information. A large

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The helpful comments of Darryl Ray and Boubaker Thabet are also recognized.

portion of the existing literature on the economics of information deals with the search for, and the use of, information by individual decision makers. Questions about the value of various types of public information systems have received less attention.

One might argue that the substantial theoretical contributions of Stigler, Arrow, and others provide an adequate theoretical basis for the economics of information. However, the theoretical developments to date do not include an analytical framework that enables us to translate this theory into meaningful empirical analysis. It is one thing to recognize that information is an economic good and should be used in amounts that equate marginal benefits with marginal costs. It is something quite different to quantify and measure empirically the marginal benefits and costs of a particular type of information. It is these analytical frameworks that are particularly lacking. However, the theoretical foundations on which to develop the analytical frameworks are far from complete.

As we move toward the development of this theory and methodology, there are several questions that will have to be answered. For example: What is information? How is it to be measured? What constitutes an improvement or an increase in information? Tomek's recent article dealing with the role of information in thin markets is an interesting approach to developing an empirical estimation process to deal with these questions.

Value of Information System to Nonmarket Users

Changes in government programs and policies can create new and added value for information. Moreover, the existence of these programs can perhaps place a premium on accuracy of data that exceeds the accuracy premium generated by market users. For example, consider the current price support program of deficiency payments equal to the difference between the target price and the annual average price received by farmers. For a six billion bushel corn crop, an error of only one cent per bushel in measuring the market average price of corn translates into a $60 million difference to corn producers, or to the U.S. treasury, if payments are triggered. The growing number of programs that depend on public data series such as the census and various USDA reports for the allocation of public funds will add to the pressures for accuracy. For example, witness the current discussion about the undercounting of populations in numerous cities.

One of the more important questions about the value of statistical information systems deals with the decisions of administrators of public information systems. Program administrators continuously are caught between the demand by users for more and better information and the pressures of costs that increase more rapidly than budgets. What is the decision framework that should be used to make decisions about changes in the public information systems?

What kind of information about the value of information is needed to make decisions about changes in these systems that are in the public interest? Can public information programs be managed effectively without estimates of information value? A dialogue between researchers and the program administrators is needed to answer these questions, if we are to contribute to this management process. "It is not enough to develop a methodology for estimating the value of information—the value estimates must actually be useful to Government managers in making decisions about information systems" (Miller, p. 5).

As well as determining the economic value of public information systems, there are two additional types of economic analysis that perhaps should be useful to these decision makers. First, there is project evaluation aimed at identifying who is using the information and how they are using it, as well as examination of the information gathering process itself. Moulton, Levinson, and Thomas concluded that "while we find it feasible to measure some benefits derived from Market News Service, we are not sure this is the direction in which to move. Our observations and analysis suggest that efforts might be directed better toward improved organizational efficiency and study of market changes influencing MNS services" (p. 66).

The second type of analysis is impact analysis. Studies like the one by Pearson and Houck are examples of efforts to provide useful information about the impact on price movements of various types of reports. Studies of this type provide answers to some of the critical questions (accusations) raised by individuals concerned about the impacts of government reports.

Value of Information to Market Users

We have numerous theoretical and methodological voids to fill in the process of determining the value of information in the market place. We simply do not know enough about the rôle that various types and qualities of information play in the effective operations of markets. Information undoubtedly plays an important role in the process of price determination, in product price variation over time and space, and consequently, in determining the efficiency of markets. But just what is the role of information in each of these areas? How would a 10% increase or decrease in information impact the effectiveness of these markets, and what would be the value (cost) of this change in information?

We have many unanswered questions about the role and, hence, the value of information in the market place. For example: How much and what type of information is required for a market to perform effectively its price discovery functions? There is widespread concern that the decentralization of markets has led to an inadequate amount of information in many markets. However, until we develop answers to the above questions, our capacity to report prices exceeds our capacity to interpret what the data mean within the context of performance evaluation. Moreover, we have little basis for suggesting changes in the reporting systems. Ward has shown that our existing procedures of interpretation often raise more questions than they answer about the performance of existing price discovery systems.

The availability of public information systems also may impact the structure of the agricultural production and processing sector (Riemenschneider). This relationship further complicates efforts to determine the value of information systems. Even if we can establish a cause-and-effect relationship between the existence of public information systems and industry structure, economic theory provides little operational methodology for estimating the value (or cost) of structural change.

The income distribution aspects of public information systems cannot be overlooked in our attempts to define the value of public information systems. There appears to be a widespread feeling among producers that information about their current and anticipated production levels results in a transfer of wealth from producers to processing firms and consumers. In some instances, producers suggest that the way to beat the "system" is to lie about their actual and planned production. Is this true? Under what conditions, if any, does the release of production estimates and producer's production intentions work to the detriment of producers, either as a group or individually? Is it in the producer's interest to report falsely current and/or planned production levels? If so, is it in their interest to inflate or deflate actual production numbers? Until we can answer questions like these, the agricultural sector may be quite skeptical of any estimates of the economic value of these data systems which we might develop.

Some Theoretical Considerations

Conventional wisdom holds that the value of information increases as its accuracy increases. This conclusion is intuitively appealing and is supported by the conclusions drawn from the Hayami and Peterson theoretical framework of the value of forecast information. Most, if not all, efforts to estimate the value of forecast information have assumed that the value of this information increases continuously with increases in forecast accuracy. However, this bit of conventional wisdom is not always true. Unfortunately, the Hayami-Peterson theoretical framework is incomplete and does not correctly identify the social cost of forecast errors. Because the incorrectness of the conclusions drawn from the Hayami-Peterson model have apparently not been widely recognized, the problem with their model is discussed below.

The Hayami-Peterson inventory adjustment model is illustrated in figure 1. "We assume in this case that production response to a price change can be approximated as being perfectly inelastic during the production period, as denoted by the supply curve *SS*. The market demand schedule [in both time periods] for the commodity is denoted by *DD*" (Hayami-Peterson, p. 121).

Note that Hayami-Peterson have failed to specify the current level of inventory holdings. Furthermore, they neglect to define how inventory holders make decisions about how much inventory should be held from one time period to the next. (Bradford and Kelegian noted this problem with the H-P model, but did not explore its implications.)

Hayami-Peterson continue the development of their model as follows. "Suppose the statis-

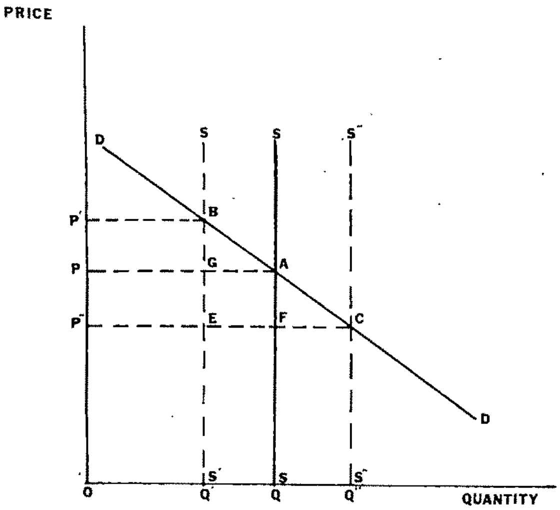

Figure 1. Hayami-Peterson inventory adjustment model

tical reporting agency estimates the current period production as OQ' as opposed to the actual or 'true' production OQ. Inventory holders, in forming price expectations for the coming period, expect the average price to equal OP'. In other words, they would expect the future price to be higher by PP' than would be the case had no error been involved in the production estimate. Consequently, inventory holders find it profitable to decrease their rate of inventory depletion for the remainder of the year, until current price has risen by PP'. Consumption then would contract to OQ', or by an amount $Q'Q$. In turn, the inventory carry over into the next production period would be increased by the same amount, $Q'Q$. As a consequence, the reduction in consumption during the current period would reduce consumer welfare by the area $ABQ'Q$" (p. 121).

There is not enough information in the Hayami-Peterson model to draw these conclusions. Inventory decisions require information about current stock levels and anticipated production in the coming period. Neither of the datum is present in the Hayami-Peterson model. If inventory holders have existing stocks at the beginning of the current period, they will find it profitable to decrease their rate of inventory depletion for the remainder of the year until current price has risen by PP' only if they have reason to believe that production in the coming period will be even less than OQ' by enough so that all inventories can be liquidated in the incoming year at a price of OP' (given the assumption of zero storage cost and a two-time period model). In the Hayami-Peterson model, carryover from the current period (current period production minus current consumption) is then consumed in the coming period along with production in the second period—there are no other inventories being held.

The Hayami-Peterson inventory adjustment model thus does not depict the normal inventory adjustment process of a market. Consequently, the area identified as social costs of forecast errors and the formula for measuring this area do not measure what they are intended to measure.

When an appropriate inventory decision framework is incorporated into the inventory adjustment model, the social cost of forecast errors can be illustrated with the supply and demand for storage services. A quite different set of conclusions is derived.

The social cost of forecast errors depends on whether production is under-forecast or over-forecast. Figure 2 illustrates the social costs generated by an over-forecast of forthcoming supplies. DD' is the demand for storage from the current period to be held into the coming period with perfect information about next period's production and the current level of stocks. DD' is defined by subtracting the excess supply curve for the current period from the excess demand curve for the next period and reflects the marginal social value of

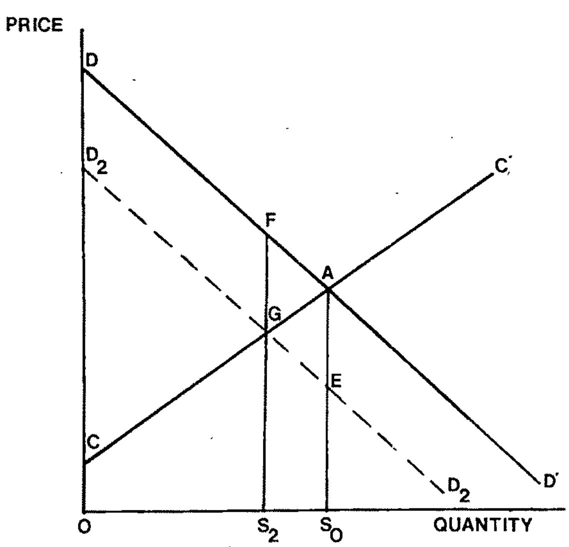

Figure 2. Social costs of forecast errors due to overestimation of production in the inventory adjustment model

alternative levels of storage (Bressler and King, p. 206–9). CC' is the cost of alternative levels of storage. With perfect information, S_0 units will be held in inventory from the current period into the coming period.

The effect of an over-forecast of next period production is to shift the demand for storage to the left to D_2D_2 and to generate S_2 level of storage and hence to generate social costs of AGF.

There is an upper limit of ACD on the social costs associated with over-forecast errors since negative inventory levels cannot be carried from the current period into the coming period. Thus, once the forecast error is large enough to shift the demand curve for storage to the point where it intersects the price axis at point C, then larger over-forecast errors will create no additional social costs. Moreover, in those cases where DD and CC intersect at low levels of storage, the social cost of any under-forecast will be quite small compared with the same degree of under-forecast in a situation where large quantities of inventories would be carried forward under perfect information.

We can conclude from these models that not all forecast errors generate social costs. In many cases, the magnitude of the social cost of an erroneous forecast is independent of the magnitude of the forecast error beyond some minimum level of error. The social cost of a given forecast error is unique to the set of supply and demand conditions existing at the time of the forecast. Therefore, it is not possible to state categorically that an X-percent forecast error will generate Y dollars of social costs. In general, the social cost of an X-percent over-forecast is not symmetrical with the social cost of an X-percent under-forecast. Consequently, the benefits to improvements of USDA forecasts depend on how the frequency distribution of forecast errors is changed (Bullock). This set of conclusions is not very encouraging for those looking for a simple formula to value information generated by forecasts.

Hayami and Peterson also developed a formula for valuing forecast errors for commodities where producers can alter output in response to the USDA report. This model is referred to as the production adjustment model. Their formula expresses the social cost of these errors as a continuous function of the average percent error and the elasticities of supply and demand for the product. Unfortunately, that is true only under special circumstances. In general, there is a discontinuous relationship between social cost and the magnitude of forecast error when producers can alter output in response to the forecast.

The conclusions about the social cost of forecast errors that can be drawn from an appropriately constructed production adjustment model are much the same as those drawn from the inventory adjustment model. That is, not all forecast errors generate social costs. In fact, there are many situations where even erroneous forecasts generate positive social value when producers alter output in response to the forecast. The magnitude of social costs (or benefits, as the case may be) are often independent of the magnitude of the forecast error over a wide range of forecast errors (Bullock).

The problem of determining the value of public data systems is considerably more complex than conventional wisdom suggests. Some type of stochastic simulation process similar to that used by Marquis and Ray may be required to estimate the economic value of these systems. The potential for this approach needs further investigation.

There are several dimensions of information—accuracy, timeliness, reliability, availability, continuity, and perhaps others. Which of these dimensions causes information to have value? Do these dimensions always have the same relative value? An adequate theory defining the value of information will have to deal with the nature of the iso-value line between alternative combinations of these characteristics. The following discussion provides a starting place for developing the conceptual framework for defining the iso-value line between timeliness and forecast accuracy.

A timely report generally is considered to be one that is available at the time the information is required for decision making. This raises the question of whether a report issued one month before the decision date is more timely (and hence presumably more valuable) than the same report issued one week prior to the decision date. Second, is there a trade-off between timeliness and accuracy in terms of the value of alternative reports?

The potential payoff to improving the timeliness of forecasts or reports is illustrated in figure 3. SS represents the preseason supply curve on which producers base their initial production decisions. DD is the harvest time (say July) demand curve for the product (assumed to be known with certainty). Suppose

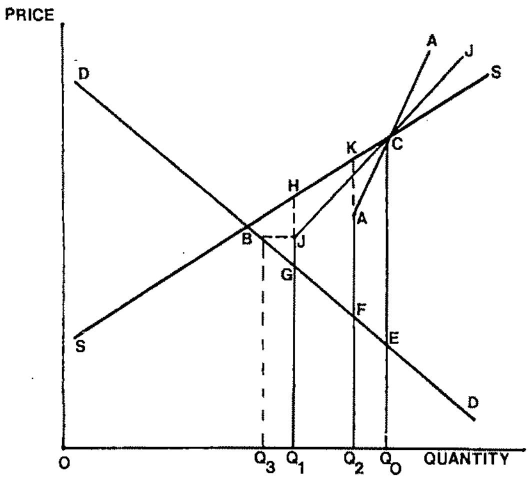

Figure 3. Illustration of potential social value of more timely forecast

that in the absence of information about the magnitude of their combined decisions, producers are gearing up to produce at output level Q_0. If no information is provided to producers about their combined decision prior to harvest time, then output Q_0 will be produced, and the resulting resource misallocation will generate social costs represented by the area *BCE*.

The extent of the response by producers to information about their combined production plans will depend on when the information is released. JJQ_1 represents the supply response if a report is released in January. However, producers would respond to the same information along the curve AAQ_2 if the information were not released until April. This implies that an acceptable alternative use of at least some of the resources exists under some conditions and that the options decrease as the time between the release of the forecast and harvest period shortens.

If an accurate report of current production intentions (i.e., Q_0) is released in January, producers will reduce output to Q_1 and, hence, the social value of the report is the area *GHCE*. However, the same report released in April has social value of *FKCE*. The area *GHKF* then represents the social value of making the information available in January rather than April (social value of timeliness). This is only part of the social value of timeliness. The social value (cost) associated with changes in the output of products to which the resources are shifted is not accounted for in the analysis. Some type of simultaneous multicommodity model will be required to deal with this issue.

There will be an economic value of improved timeliness only if the production decision is reversible to some degree over some time interval. Moreover, the degree of reversibility must decrease as each stage of the decision process passes as reflected by the differing slope and range of possible output response depicted between JJQ_1 and AAQ_2. Therefore, there is a limit to the amount of improved timeliness that will generate social value. When the report is issued to be timely for the *SS* stage of the decision process, no further gains in social value will be generated by making the report available at an earlier date.

The above analysis assumed a perfectly accurate forecast in either January or April. However, any forecast greater than or equal to Q_3 would have obtained the same response as a perfectly accurate forecast. Thus, at least in some instances, there may be substantial payoff to making inaccurate information available at an earlier date rather than waiting to release accurate information at a later date. There would appear to be, in many situations, a trade-off between accuracy and timeliness. However, it is not at all clear what would be the shape of an iso-value line drawn between level of accuracy and timeliness of the report. The shape is likely to vary from one report situation to the next.

Unfortunately, there is a measurement problem that prevents us from empirically estimating the iso-value curve. The measurement of forecast errors is impossible in cases where the production adjustment model is applicable. Prior production plans are not observable (even *ex post*). In the above example, the true forecast error is zero (i.e., the forecast correctly identified Q_0 as the level of planned production). However, the observed forecast error is $Q_0 - Q_1$ or $Q_0 - Q_2$, depending on when the forecast is released. However, if the forecast had been Q_1 in January or Q_2 in April, the observed forecast error would be zero even though an incorrect estimate of Q_0 had been made. There appears to be no definite relationship between actual and observed forecast errors. Thus, there appears to be no way of determining the level of accuracy for the type of reports depicted in the inventory adjustment model.

Work to date has been with either an inventory adjustment model where producers can-

not adjust output in response to the U.S. Department of Agriculture report or a production adjustment model where no inventories are being held. However, there are numerous situations where a combination of these models will be required for meaningful analysis. The development of more appropriate models is an area of research that needs more attention.

Conclusions

This paper has attempted to identify some of the questions that need to be answered about the value of information. The nature of these questions indicates that there are four types of activities that are needed if we are to make improvements in our agricultural data system.

The first activity is further development of the theoretical and methodological framework for measuring the value of information. Our theories and knowledge about the information requirements of economic activity conducted in a dynamic and less-than-perfect information environment are inadequate to answer some of the questions being raised about our information systems. The second area is expanded collaboration between researchers and managers of public information systems in order to determine what type of information about the value of information is needed for effective management of these systems. Third, program evaluation efforts should provide useful information about ways to improve the operational efficiency of the information systems. The fourth area is impact analysis and extension programs to enhance the general public's understanding about the nature of the benefits generated by these systems.

The focus of this discussion has been on questions related to determining the economic value of public information systems. Developing such measures is a formidable task, and it would be easy to conclude (somewhat prematurely) that dependable, quantitative estimates are not likely to be developed. However, even if this is our final conclusion, the information to be gained by pushing back the frontier in this area is required for answering many of the questions raised above. We will need to understand why such measures cannot be developed. We also will need to identify what other types of information are required to design and manage effectively information systems. Research related to expanding our understanding of the role and value of information in economic activity should be of high priority to economists.

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Farm Sector Data: Presentation and Improvement

Kenneth J. Nicol

Economic data for the farm sector are developed by the U.S. Department of Agriculture's (USDA) Economics and Statistics Service (ESS). The economics unit is responsible for outlining the data needs. It works with the statistics unit to collect basic data not available in conjunction with other data projects or from other government agencies. Presently, the economic well-being data are collected and published by the Economic Indicators and Statistics Branch of ESS. These data include the balance sheet, farm income, agricultural productivity, and cost of production series.

Balance sheet data have been developed since 1945 and the farm income estimates from 1914. Both series (and other data as well) were developed to reflect the aggregate sector status for a period in history when many farms were structurally uniform. Changes in the agricultural production sector's structure have made these aggregate estimates less useful as indicators of the economic well-being of the sector. Disaggregations of the sector's aggregate economic data were made reflecting the size distribution based on farm gross sales and geographically based on state location of the farm.

These disaggregations reflect some aspects of these sectors' economic conditions, but other aspects that can substantially influence the true status of the subsector being evaluated, are not reflected. Cyclical patterns in product prices affect farms selling or buying the product but have less effect on farms producing substitutes or not involved in the product's market differences.

During the past ten years, concern about the validity of the data being reported arose and reviews have suggested many changes in the present economic data systems. These reviews and discussions with government staff members and members of the academic community have formed the basis for a set of economic accounts which can overcome many of the shortcomings of the present system (Nicol 1980b). Concurrently, a project to review the data available to modify these accounts has been implemented and a two-phased product produced. Initially, the account formats are being implemented to the extent possible with available data. The second phase was to identify the data needed to implement fully the accounts (Nicol 1980a).

This paper presents a review of the economic data projects and their recommendations. The first item covered is a clarification of the definition of the sector. This is followed by a description of the set of accounts and a discussion of the data needed to implement fully these accounts.

Definition of The Farm Sector

The agricultural production sector for this analysis is defined as the population of all farms meeting the USDA's farm definition. A farm is any establishment producing, or having the potential to produce, a minimum of $1,000 of agricultural products. The activity of the farm to be measured is the total economic activity of the establishment. Activity associated with the movement of a product from site of production for the purpose of transfer of ownership or for movement through a marketing channel or processing facility constitutes movement from the production sector. This distinction is made to separate the component parts of integrated enterprises while allowing the production sector to move commodities to off-farm storage with the intent of influencing market timing. Movement of the product into storage or transport with the intent of altering the locational or physical attributes of the product is associated with the marketing or processing sectors.

Where possible, the production process is being reported separately from the activity of

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the household or farm family controlling the establishment. This eliminates the need to measure other activities of the household and report them as part of the farm's activities.

Identification of the Economic Data

The economic data needed to measure the income and assets of the production sector have been organized into a set of four accounts. These accounts are an asset account (detailing asset type and financing), an asset flow account (reflecting asset purchases and uses), a production or income account (in a value-added format), and a cash transaction account (representing the flow of funds in the sector).

These accounts have been defined so that disaggregations of the aggregate sector can be made using the same account formats. Emphasis for the disaggregations are being put on size using value-of-sales class, geographic location based on states, and product specialization based on the Standard Industrial Classification breakout for the agricultural sector.

These account formats also can be used as a basis for reporting the activity of the farm's controlling institution. These institutions can be defined on legal identity (corporation, partnership, sole proprietor, or other) or on functional purpose (family farms, corporations, or other). Other disaggregates based on the characteristics of the controlling institution also can be made when the required information is available. Examples include operator equal opportunity characteristics, degree of reliance on farming, or tenure.

The Asset Account

The asset account (table 1) brings together the data associated with the farm establishment physical and financial assets, and loan and equity liabilities. The data in the asset account cover only the assets used in the production process (which are owned by the farm business). Assets used by the household for personal living are not included. Assets owned by the service sector and rented, leased, or hired by the farm establishment are not included because they receive a return generated by the income flow of the agricultural production service sector.

The Asset Flow Account

Changes in the asset value in the farm sector result from the interaction of two specific components—prices and quantities. The emphasis of the data in the account concentrates on the physical assets of the sector (table 2). Changes in financial assets are incorporated into the cash transaction account. Asset formation is the sum of fixed-asset formation and inventory adjustments. Asset utilization (disappearance) involves depreciation, accidental damage, sales, and net capital growth.

Table 1. An Asset Account for the Farm Sector

Assets	Liabilities
I. Physical assets	I. Loans
A. Capital	A. Loans for capital purchase
1. Land	1. Real estate
2. Buildings	2. Machinery
3. Machinery	3. Livestock
4. Livestock	B. Loans for operating expenses
B. Inventories	C. Government loans
1. Inputs	1. Commodity programs
2. Work in process	2. Disaster loans
3. Finished goods	3. Other (conservation, pollution)
4. Crop held as CCC loan security	II. Accounts payable
II. Financial Assets	III. Equity
A. Currency	A. Corporate
B. Demand deposits	B. Book value
C. Savings	C. Retained earnings
D. Investment in cooperatives	D. Proprietor's equity
III. Accounts receivable	IV. Total liabilities
IV. Total assets	

The Production Transaction (or Income) Account

This account provides data on the value of products produced and the allocation of the value to inputs and resources. The account reports income in a format that is generally compatible with the national income and product accounts of the U.S. Department of Commerce (table 3). The major function of this account is to measure the output and input of the sector on a value-added basis rather than on a sales and purchase basis. As part of this value-added emphasis, the reporting of CCC loans is being changed. Commodities placed as security for CCC loans previously have been considered as sold. In the new system the commodity is reported as an income source when it enters inventory or is sold. The subsequent transaction with the CCC is a loan secured by the commodity and enters the sector's cash flow account and has no immediate effect on income. It subsequently may affect income as the farmer pays storage and interest or forfeits the loan to the CCC at a loan rate above the present inventory value of the commodity. The activity of the loan received is accounted for in the sector's cash transactions.

The Cash Transaction Account

Not all income, as reported in the production account, is realized as cash available for payment of farm obligations. The cash transactions account (table 4) reports data which illustrate various levels of cash inflow and disbursement. The cash flows of the agricultural production establishment and the operator household are closely related, especially for sole proprietor establishments.

This account reports data which measure the cash components of the production account and supplements these sources and flows with loan activity information. These data will illustrate the impacts of net changes in inventory and CCC loan activity on the operator's available cash levels. For the disaggregated sector report, the data illustrate the impacts of outlays for capital, including land, and how the fixed-payment commitments of some of the subsectors vary in importance and affect the establishment cash available in response to relative price shifts.

Measurement of Operator Well-Being

Measuring the well-being of the farm operator is a necessary component to reflect adequately

Table 2. An Asset Flow Account for the Farm Sector

Formation	Disappearance
I. Fixed-asset formation	I. Capital consumption
A. Own account formation	A. Depreciation
1. Replacement livestock	1. Buildings
2. Construction of buildings	2. Machinery
3. Land improvements	3. Livestock
B. Purchases	B. Accidental damage
1. Land	1. Buildings
2. Buildings	2. Machinery
3. Machinery	3. Livestock
4. Replacement livestock	II. Sales of capital items
C. Valuation adjustment	A. Within the sector
1. Land and buildings	1. Land and buildings
2. Machinery	2. Machinery
3. Livestock	3. Livestock
II. Changes in inventories	B. To other sectors
A. Net value of quantity change	1. Domestic
1. Inputs	2. Foreign
2. Work in process	III. Net capital growth
3. Finished goods	IV. Gross capital disappearance
B. Net value of price change	
1. Inputs	
2. Work in process	
3. Finished goods	
III. Gross capital formation	

Table 3. A Production Transaction Account for Agriculture

Allocations	Sources
I. Intermediate products[a]	I. Sales
A. Purchases of farm products	A. Agricultural products
1. Feed	B. Other products
2. Livestock	II. Other incomes
3. Seed	A. Government payments
B. Purchases from other sectors	1. Program payments
II. Gross value added[b]	2. CCC loans guarantee payments
A. Capital consumption	B. Other
B. Business taxes	1. Insurance
C. Net income at factor costs	2. Interest and dividends
1. Labor compensation	3. Rents
a. Hired laborers	III. Own-account uses
b. Operator and family labor	A. Final demand
2. Return to land and buildings	1. Operator family
a. Rent to landlords	2. Employee perquisites
i. Nonoperator landlords	B. Fixed-capital formation
ii. Operator landlords	1. Breeding livestock
b. Return to operator assets	2. Own-account construction (buildings, land improvement, orchards)
i. Real estate interest	C. Change in inventories
ii. Corporate asset return	1. Inputs
iii. Operator return	2. Crops
3. Capital return	3. Nonbreeding livestock
a. Non-real estate interest	IV. Total Sources
b. Return on operator capital	
c. Corporate capital return	
4. Management return	
a. Hired	
b. Operator	
5. Entrepreneurial return	
III. Total allocations	

[a] Includes inputs for production of ancillary and secondary products.
[b] For compatibility with National Income Accounts, rent paid must be included as an intermediate product purchase from the real estate sector.

Table 4. A Cash Transaction Account for the Farm Sector

Cash Sources	Cash Uses
I. Cash sales	I. Production expenses
A. Agricultural products	A. Intermediate products
1. Crops	1. In sector
2. Livestock	2. Intersector
B. Ancillary products	B. Resource payments
1. Custom work or machinery rent	1. Cash wages and salaries
2. Recreation	2. Cash rents
3. Rents	3. Interest payments
4. Interest and dividends	II. Capital goods purchases
C. Sale of capital items	A. Land and buildings
II. Government payments	B. Machinery
A. Program	C. Livestock breeding animals
B. Other	D. Land improvements
III. CCC loans initiated	III. CCC loan payments
IV. Other loans initiated	IV. Other loan payments
A. Real estate	A. Real estate
B. Non-real estate	B. Non-real estate
V. Financial asset changes	V. Net investments
A. Changes in the sector	VI. Assets of operators existing the sector
B. New assets entering the sector	VII. Total cash uses
VI. Total cash sources	

the status of the farm sector. Many operators supplement their income and cash flow of the establishment by off-farm incomes. The farm operator income account (table 5) presents data to evaluate the farm and off-farm sources of incomes for the operator. Other institutional forms also can be the basis for this type of account. Included may be operators by legal form (corporation, sole proprietors, partnership, and other), operator by reliance on agriculture for income, or other socially and politically relevant category.

Data Needs to Fully Implement the Accounts

Data needed to modify the existing income and balance sheet programs to allow for a more complete report as outlined in these accounts include both sector level and data series issues. The data series issues relate to the definition and reliability of specific data elements. Many of the reported series are estimated from secondary data sources or from arithmetic operations with a set of these data sources. The concerns that arise as a result of this method include complete compatibility of each series, ability to keep the series current, and the possibility of loss of continuity as the data collector's priorities change.

The major emphasis in the rest of this paper will be on the sector level data needs. These needs are by implication relevant to the individual data series. Specifically, the issues include establishment definition, inventory accounting, operator interaction, and subsector disaggregations.

Establishment Definition

The definition of which establishments are included in the sector defines the population of farms for the agricultural sector. The official definition of a farm includes all establishments that produce, or have the capability to produce, $1,000 of agricultural products. This varies from the Department of Commerce National Income and Product Accounts establishment, where the classifications are based on the SIC commodity or commodity group that accounts for at least 50% of the establishment's sales.

At present, much of the economic data for the farm sector are collected at the market channel level and the flow of goods is not identified directly with the establishment marketing or purchasing the commodity.

Inventory Accounting

These data concern three components of the inventory reported on the farms. First is the interaction of the goods held for input or marketing and the goods held as production assets. The second component of inventory is the reporting of commodities held as CCC loan security and is being modified. The third is the identification and measurement of input inventories.

The present accounts report land, buildings, and machinery in capital assets with breeding

Table 5. Farm Operator Income Account

Allocations	Sources
I. Expenses of operators	I. Farm income
A. Dwelling expenses	A. Labor
B. Business associated	B. Return on land
II. Net family income	1. Production return
A. Tax and nontax payments	2. Capital gain on land and buildings
B. Social security payments	C. Capital return
C. Net disposable income	1. Return to working capital
III. Total operator allocations	2. Value change of machinery inventory
	D. Management
	E. Entrepreneurial return
	II. Imputed rental value of dwelling
	III. Nonfarm income
	A. Wages and salaries
	B. Business incomes
	C. Interest, dividends, and rents
	D. Transfer payments
	IV. Total operator income

herds included in livestock inventory. The livestock inventory is to be separated into capital livestock, animals, or birds held for the product they produce, not primarily for sale. The other animals in inventory will be those held for sale, such as broilers, feeders, and animals on feed.

Now the inventory levels for both the capital and production livestock can be identified and values determined. The major data concern is the identification of the flows of livestock. Measuring marketings at the market channel level makes identification of the prior or proposed use of the animal difficult to identify. Is the animal being sold out of a breeding herd as a cull or as a capital item from the production inventory? Young animals will remain in inventory until introduced into the breeding or milking herds. Thus, heifers sold may be for feeders, calf slaughter, or eventual entry into a herd.

The impact of the change in CCC loans, shifting from an assumed sale to a loan with commodities for collateral, requires more data than the previous net change in value of loans outstanding. The quantities of the commodities under loans must be identified as well as the market value of the commodity and its loan rate.

The measurement of input inventories has not been a part of the sector's data reports in the past. The increased use of current cash to purchase next year's inputs before the end of the calendar year potentially can have impact on fertilizer, seed, or fuel purchases. Under the present basis for calculating these items, little fluctuation may occur as their use is based on need rather than marketings. However, as more establishment data become available, especially from surveys like the Farm Production Expenditure Survey (FPES), the potential for error is greater. If the input is considered an expense before the product is marketed or included as inventory, a larger expense is measured with no receipt to offset this outlay.

Operator Interaction

In the discussion on the operator account, reference was made to the need for data which allow for separation of the production establishment and its controlling institutions. Most reference is made to the operator with connotations of the sole proprietor or family farm. Corporation, partnership, or other legal entities also can act as operator institutions. Policy consideration may suggest the separation of the family-held corporation from the multishareholder corporation. Data are needed that separate the assets between those used for production and those used for operator-household living. This would mean separating operator dwellings, household furnishings, and household financial assets from the assets presently identified in the ESS Balance Sheet Project. Separating off-farm income and other income flow associated with the household from the present receipts also is needed. This transfers the imputed rental value of the dwelling to the operator account from the farm income statement. As the needed data are collected, a more accurate representation of the sector production activity and its relationship to the assets will be available.

The household disaggregation can be separate or it can be added directly to the disaggregation of the establishment accounts. The second form of disaggregation needed emphasizes the establishment and is based on its characteristics.

Subsector Disaggregation

Present disaggregations include states and value-of-sales class based on gross sales. Cyclical patterns in relative prices encourage the development of more disaggregation, especially those based on farm type. The state and farm size disaggregations are based on census benchmarks as are the value-of-sales class distribution procedures. The geographic distribution based on states also is developed from the total and disaggregated.

The cyclical patterns in prices causes the duration and magnitude of sales to vary. In order to evaluate the well-being of the various farm establishments, both the relative and absolute effect on various subgroups are needed. The procedure being implemented will base a farm-type disaggregation on the SIC agricultural establishment categories. At this time only the disaggregation of establishments by type, value-of-sales class, and state will be implemented.

Data Collection

The major data issues to be discussed concern the concepts outlined above. Data for each series must be evaluated for accuracy and

compatibility with the other series. Data for the major structural changes are being developed by modifications to existing data sources or by developing new data collection projects. Some of the major effects are discussed by principal area of concern.

Establishment Definition

Little new data are needed except where surveys reflect the entire population of farms on the old USDA farm definition. In many instances, the series used have been modified to the $1,000 criteria.

Inventory Accounting

Most of the flow data for the inventory accounting needs cannot be developed from presently available sources. While the actual levels can be determined, flow data are needed on sales and purchase of various types of livestock by source or use. Modifications have been introduced to the annual FPES of ESS. As planned, these data will adequately reflect the flow on the purchases side. No data are available for the sales of commodities from capital stock. This shortage may be overcome if the Economic Industries Survey (EIS) is implemented next year, as proposed. This survey, in conjunction with the present asset data and the FPES as modified, should facilitate the inventory calculations.

A second data need is the CCC loan activity on a gross basis for calculation of the loan and cash flows. A program has been initiated with the ASCS Kansas City office to receive the necessary data. Emphasis is on the level of loan activity and its impact on flow funds.

Operator Interaction

This section, which would break out the activity of the operator institution from the farm production establishment, has the greatest data shortcoming. Much of the problem is associated with the lack of data other than the Census of Agriculture. This is only available on a five-year schedule and leaves much to be desired in terms of reference and reliability.

Subsection Disaggregations

The major data issue is the availability of classifiers on the survey which collects the data. Type classifiers already have been added to the FPES and are being included in the new EIS. A tentative procedure would be to develop scalers which would distribute the aggregate series.

Data Compatibility

With most every data series originating from different primary data sources, some consideration has to be given to compatibility of the series. Different collection procedures, sampling rates, and processing can affect the accuracy of the calculated series.

A proposal which may solve this compatibility issue would be to modify completely the use and function of the census. The present census could be used primarily to identify the establishment population, stratify it, and develop sampling weights for a series of census follow-on surveys. These follow-on surveys would collect the necessary data and be conducted each year based on a census sample. The annual follow-on surveys could keep track of each establishment and follow it through transfers to maintain its sample.

A program like this would allow for elimination of some surveys presently conducted and, most important, keep all series based on common sampling procedures and population definitions.

Summary

The data for evaluating the economic status of the farm sector have not historically been modified to reflect changes in structure and emphasis of the sector. The project undertaken in ESS has attempted to identify the issues, develop a framework, and implement the system including the collection of new data necessary to quantify the system. At present, the program is in the implementation stage, with the 1979 economic data being presented in the new framework where data permit. Also, new surveys, changes in existing surveys, and discussions with the Bureau of the Census on its role have been initiated to help overcome the existing data needs.

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Changing Rural Development Data Needs: Discussion

Peter M. Emerson

In their paper on the changing nature of data needed to understand the economic and social affairs of rural people, Bonnen and Nelson have confronted an important challenge. The strengths of the paper originate from the authors' insistence that a successful data base—including the definition of concepts, inquiry, measurement, and tabulation—can be derived only from a sound theoretical understanding of the relevant information system, and from their explicit recognition that social science data tend to become obsolete as a result of changes in technology and institutions and as a consequence of the "learning" (or adaptive) aspects of the information system itself. Others before them have emphasized that an analytical hypothesis and the data for its empirical test must have the same definitional base (Morgenstern, p. 62–64). However, this still needs emphasizing to some economists and sociologists, who too often show relatively little interest in survey design and data collection, preferring, it seems, to devote their time to the sophisticated manipulation and analysis of inappropriate data.

The authors argue rather convincingly that the deficiencies of existing rural data are due not to a lack of knowledge about data gathering, or a shortage of funds, but to a lack of "an intellectually coherent, widely accepted normative vision of the future of rural society." This, they contend, is caused by our inability to resolve the social value conflicts inherent in rural development and by the very rapid, technologically induced, changes that are taking place in rural society. To help solve this problem, they offer a unique explanation of the evolution of rural development policy as an attempt to remedy imbalances among major social values, together with a more traditional discussion of new technologies and changes in social institutions that have created an urbanized rural society.

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The paper provides an interesting conceptual overview of an ideal rural information system. Yet, after discussing the increasing heterogeneity of rural society and the lack of agreement on development objectives, Bonnen and Nelson provide no specific suggestions to assist us in the difficult task of achieving a consensus on rural data needs. Thus, they do not move us much closer to understanding the specific dimensions of a practical rural data base.

I think this shortcoming is related to two major weaknesses of the paper. First, the authors do not discuss the kinds of key decisions in which information derived from improved rural data would find a use. At first glance, it seems likely that information requirements vary greatly among potential users. Small town mayors, regional planners, federal program administrators, policy officials, and researchers are all interested in rural development data. But Bonnen and Nelson do not say whether there are any common threads linking their data needs together.

Without a better understanding of key decisions, of the probability that certain events will occur once a decision is made, and of the payoffs one can expect, there is no way of being certain that improved or new data actually will influence the rural development process and generate a positive return to society. Early in the paper we are told that the nonfarm rural population can no longer be ignored—that we may have devoted too many resources to collecting data on the commercial farm sector. Yet, it has been estimated that each dollar spent to increase the accuracy of USDA crop production estimates will return at least $100 worth of benefit to society (Hayami and Peterson, p. 128). Can Bonnen and Nelson claim a similar return for additional investment in rural development data? Can anyone demonstrate that a further expenditure of funds on social and demographic statistics, say more comprehensive data on rural housing condi-

tions, would be likely to yield a greater return than a similar expenditure of funds to improve a more widely used data series such as manufacturers' new orders or some other important economic indicator?

A second weakness of the paper is that the authors do not categorize, inventory, and critique existing rural data in a manner that leads to specific suggestions for improvement. These data are collected and reported at substantial cost to private citizens, businessmen, and government agencies, and used to encourage remedial action. A first order of business should be to decide how we can improve the existing rural data series. Do certain kinds of data appear too infrequently? Are they inaccurate? A second order of business should be to determine what data series are incomplete or irrelevant. What new series are needed, and what existing series could be eliminated?

Given the lack of agreement on development objectives, the local nature of many rural problems, and the high cost of data, I certainly agree with the authors' conclusion that our current strategy for improving rural data should be experimental and flexible. Bryant has suggested that "emphasis should be on diverse small experimental and pilot projects which would simultaneously develop theoretical concepts for area and regional planning and analysis, their empirical statistical analogues, and methods of data collection" (p. 417). Under such a decentralized approach, attention should be directed to coordination—at the national level, perhaps—in order to guarantee wide accessibility to data and to exchange information about work in progress. Bonnen and Nelson have pointed out that it is important to adopt procedures that will ensure the technical credibility of data, and to guard against efforts to politicize the activities of problem definition, inquiry, and reporting. Nevertheless, I think these problems will be especially difficult to control under a decentralized approach.

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Some Concepts for Measuring the Economic Value of Rural Data: Discussion

Thomas A. Miller

Bullock has provided an excellent overview of the information value question as related to rural data. The audience has been guided to a number of concepts or areas that warrant in-depth study. I feel the following two points deserve special emphasis:

(*a*) The primary reason we are interested in the economic value of rural data is to improve our rural data systems. Improved management of public information systems requires a knowledge of the role and value of the information being produced. The management needs of public information system managers should be the focus of future research on information value. What information about the economic value of rural data is really needed to manage effectively these systems?

(*b*) The theory related to the value of information is abstract and complex. It provides little toward a practical analytical framework for empirical analysis. A specific piece of information may be used by many different decision makers in many different ways—an overwhelmingly complex empirical problem. There is no simple formula to measure its economic value.

Beyond emphasizing these points (and others if space permitted), I have no quarrel with the remainder of the paper. Instead, I would like to consider two additional topics: (*a*) the possible structural impact of information and (*b*) the process of choosing between information systems.

Bullock briefly refers to the distributional and structural impact of information—this area deserves considerably more attention. I suspect that public rural data systems have a substantial and often overlooked impact on the structure of U.S. production agriculture, specifically among farms of different sizes.

Beginning in the eighteenth century, American agricultural policy has been to foster a decentralized, atomistic, competitive agriculture. Early in our country's history, an agriculture characterized by numerous small firms was viewed as a primary means of obtaining a competitive structure in the overall economy. Thus, I believe the USDA rural data system was designed in part to promote a highly competitive, atomistic agricultural sector. Any discussion of the role of rural data, therefore, is incomplete unless it considers the question of how these information systems affect the structure of agriculture.

A look at information economies of size is helpful in answering this question (Wilson). Substantial economies of size exist in information production. The production and acquisition of information involves high fixed costs. Furthermore, information production is a risky enterprise, and information producers face both the possibility of producing useless information, as well as the possibility of producing no information. Because outside insurance generally cannot be purchased to offset this risk, a firm must be large enough to internalize the risk of losses from information production before it can produce information through its own data collection and analysis (Riemenschneider).

This combination of high fixed costs and risk leads to substantial economies of size for information production; and information economies of size contribute to firm economies of size. Only large firms can afford to produce and effectively use information, and this activity increases their efficiency. Small firms are unable to produce information—and in the absence of public information—become inefficient in their decision making and lose their competitiveness. Information economies of size thus tend to encourage the development of large firms (created through both horizontal and vertical integration) and may contribute to industry concentration. Many examples could be given; the multinational grain companies may be an example in agriculture.

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But society can offset these information economies of size. Public information systems produce a public good to be freely used by all. The advantage of large firms in information production is offset, and small firms become as efficient in the access to information as large firms. If this reasoning is correct, the public information systems of the U.S. Department of Agriculture (USDA) and other agencies producing rural data may currently be one of the major factors slowing the further concentration of agricultural production. If society values a competitive, family-farm type of agriculture, an important value of our public rural data systems may be their contribution to agricultural structure.

Valuing this contribution is difficult. As Bullock points out, "Even if we can establish a cause and effect relationship between the existence of public information systems and industry structure, economic theory provides little operational methodology for estimating the value (or cost) of structural change." So we are left with a challenge. Public information systems may be an important defensive weapon to preserve the family farm. Can the effectiveness of our rural data systems be improved in this regard?

A second topic overlooked by the paper concerns an additional challenge—how decision makers choose between alternative information sources. Bullock notes that the perfect knowledge assumption of perfect competition has led economists to ignore the role of information. My concern is that even when we have considered the role of information, most applied studies have merely assumed decision makers use the existing (or improved or best) information. This practice overlooks the critical real world question: Do (would) decision makers actually use the specific type of information being evaluated or base decisions on some other information?

The Hayami-Peterson work reviewed by Bullock provides a typical example. They assume decison makers base expectations and decisions on one specific forecast, regardless of its accuracy. This assumption guarantees a substantial value to accurate forecasts, if we accept the benefit model. Instead, the assumption should be the focus of empirical research, more than the benefit definitions or quantities involved.

I have designated this process "the information choice model" (Miller, p. 256). Decision makers, farmers, and consumers are often deluged with information and base decisions upon only a fraction of the total amount available. This is certainly true in production agriculture. For any information category, farmers are deluged with information from different sources—USDA, farm magazines, universities, Department of Commerce, *Wall Street Journal*, and industry associations, among others. Decisions likely are made on the basis of some of this information, but never on all of it, and seldom on the "best" information available.

Several factors influence the choice of information to obtain and use in a specific decision-making question: (*a*) the cost and difficulty of obtaining and using each specific piece of information, (*b*) the perceived reliability of the different information sources, (*c*) the economic climate within which the decision maker operates, and (*d*) the nature and importance of the particular decision being made. Each of the multitude of available information sources has a unique acquisition cost as well as a perceived value to the decision. A decision maker chooses the specific pieces of information to use in each decision based on such factors.

Because many public information programs, even rural data systems of USDA, overlap with other private and industry information production systems, the marginal value of a specific piece of (rural) data depends primarily on the extent of its use and then on the private and social value of that use. Assuming the answer to the first question limits the usefulness of answers to the second question. A major part of future research on information value must be to understand how decision makers select information and form expectations based on this information.

Bullock's paper and this discussion outline a formidable challenge. The need, however, is important, and the research warrants increased attention.

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Farm Sector Data: Presentation and Improvement: Discussion

Richard D. Rodefeld

While I found considerable merit in many of the proposals advanced here today by Nicol, I also encountered a number of questions or issues that I would like to enumerate briefly for author and audience to consider.

While not questioning the importance of macro and micro data on farm enterprise and operator assets, liabilities, and this change over time, it would be useful to the reader if the author had located the concerns focused upon here within the broader context of farm sector data needs. Other types of economic data and a myriad of noneconomic data may be called for. Also, while enterprises, business owners (or operators), and their families are major components of the farm sector, there are others as well. For instance: the farm population, farm geographic and political areas and communities, and farm work force members who are not farm business owners (i.e., nonoperating farm land and capital owners, hired organizational and operational managers and hired workers). While the need for the types of data Nicol proposes quite likely are obvious to most, a brief review of the reasons for giving high priority to work on these—as opposed to other issues—would be useful.

While Nicol addresses numerous conceptual and measurement issues, others remain. I agree that major changes have occurred in both farm size and specialization—numerous other farm structural changes also have occurred. Examples are the increasing transfer of functions to nonfarm entities, increasing separation of farm business and asset ownership, management, and labor, increasing reliance of smaller operators on nonfarm income, increasing irrigation, changes in input quality, and increasing numbers of farm firms organized as corporations. What is the rationale for identifying increased size and specialization, rather than one or more of these other changes, as the "main changes in structure" that have influenced the effectiveness of present aggregate data? If these other changes have had an impact on this data, then, should they not also be measured more effectively? Also, is there not a need for greater disaggregation of these criteria as well?

It is not yet clear how Nicol has defined the concept of "farm." It can be defined either as a unitary business firm or as an operating unit. These are not the same because firms may have more than one operating unit. There may be growing utility for enumerating and studying both units. While the unit employed has no impact on the national aggregate data reported here, it does have implications for average farm unit characteristics and levels of resource concentration. If the unitary business firm is the proposed unit, then this is at variance with the Census of Agriculture, which enumerates and reports on operating units.

Also, it is not entirely clear how the concept "farm operator" is defined or if it is defined and measured consistently within the farm work force. It may be defined as the "business owner" (i.e., the individual or legal entity that owns) or as the individual(s) or family(ies) in charge of day-to-day operations. Because farm business owners and operational managers are not always the same, it is important to specify which one is the focus and develop rationales, definitions, and procedures to insure unit constancy.

Nicol implicitly recommends that the farm operator i.e., entity in charge, be defined as the farm legal entity, i.e., sole proprietorship, partnership, corporation. It is not clear at the individual level, however, whom he views as the operators of farm partnerships and corporations. In sole proprietorships, it is clearly the solitary individual or family proprietor. Individuals occupying analogous positions in the other two types would be the individual or family partners and shareholders, i.e., the farm business owners. If this is the case, then,

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to be consistent in the construction of accounts should not the farm-related assets, liabilities, production, and income, of these business owners also be included. As the proposals now stand, there is no logical place either to identify or to report the characteristics of the individuals owning (operating?) partnerships and corporations. If I understand, farm assets owned by a family that rented these to a corporation (in which the family was the sole shareholder) would not appear in the farm asset account. Thus, data reported for proprietorships, partnerships, and corporations will not be comparable.

Another problem here is that the Census of Agriculture defines the "farm operator" as the person in charge of the day-to-day farm activities (i.e., the operational manager). While most are business owners, hired, nonowning managers also are included. There is some evidence of increasing divergence between farm business and asset ownership and management. If so, information reported on farm operator characteristics by the Census of Agriculture and that resulting from Nicol's proposal will decline in comparability with time.

The author suggests at one point that "where possible, the production process is being reported separately from the activity of the household or farm family controlling the establishment." This clarifies data analysis and interpretation and allows for the separate analyses of both entities. Establishment data analysis is complicated by the fact that some establishments have multiple operating units within and across states. These numbers may be increasing. Identifying, collecting, and analyzing the characteristics of "controlling households and families" is problematic since there are farm firms (*a*) where no one nuclear or extended family controls or provides majorities of business and asset ownership and/or managerial decisions, (*b*) which have different business and asset owners, organizational, and operational managers, or (*c*) which are owned (controlled) by other firms (which may or may not be controlled by one household or family).

The analysis of household data (or separation from firm data) could be restricted to those firms owned and controlled by one family. However, this seems inconsistent with Nicol's objective of improving the effectiveness of farm sector data. Some evidence shows increased ownership and control of farm firms by extended families and groups of unrelated individuals.

At one point, Nicol equates family-owned farm businesses with "family farms." While there appears to be a trend toward such a definition in some quarters, it is at considerable variance with most past definitions. While all or most past definitions agree that ownership of the farm business by a farmer is a necessary condition for a "family farm," few or none identify this as a sufficient condition. Other necessary conditions often specified are that the farm business owners also own all, most, or some of the farm land and nonland resources; make all or most of the farms organizational and operational decisions; and, do all or most of the farm's physical labor outside seasonal fluctuations. While high and reasonably constant proportions of all farm businesses continue to be owned by an individual or family—decreasing proportions possess the other traits at high levels.

Briefer comments include the following. First, the treatment and location in the accounts of livestock and crops grown on a custom basis or provided by integrators are unclear. Second, in a recent AAEA-USDA task force report entitled "Measurement of U.S. Agricultural Productivity," numerous conceptual and empirical problems are defined for many of the items included in the accounts presented by Nicol; however, Nicol does not identify or discuss many of them. The AAEA-USDA report may merit some more attention.

Achieving Economic Efficiency and Equity in International Agricultural Trade and Development
(Kenneth Nobe, Colorado State University, Presiding)

The Role of the Multinational Corporation

Ray Goldberg

The purpose of this paper is to evaluate the role of the multinational corporation in achieving economic efficiency and equity in international agricultural trade and development. In evaluating this institution, I prefer broad and rather imprecise definitions: "a cluster of corporations of diverse nationality joined together by ties of common ownership and responsive to a common management strategy" (Vernon, p. 114) or "all enterprises which control assets—factories, mines, sales offices and the like in two or more countries" (United Nations, p. 158). These institutions may be privately, publicly, cooperatively, or governmentally owned and have their principal headquarters in either a developed or a developing country. The strength of each entity depends on its ability to provide market access, raw material procurement, appropriate technology, management, financial packages, risk management, logistics, and coordination to a global food system in an efficient and profitable manner that is responsive to the economic, social, and political priorities of the governments of the nations in which it operates. The strategies of multinational entities are affected more by individual governmental actions than by any other factor.

Governmental Priorities

Each nation is concerned that food, energy, and credit policies fit into its political and social priority system. These priorities include food price stability for consumers and producers; national security and avoidance of too much dependence on outside suppliers; economic stimulation for the general economy and use of underutilized human resources; avoidance of major change in food prices that then become part of a formal cost-of-living increase, which in turn fuels wage and other settlements adding to inflationary pressures; policies that affect the nutrition of a country, such as shipping out needed basic food supplies while importing less essential food items; policies that encourage energy efficient food production, processing, transportation, and distribution; policies that balance human and animal energy with fossil energy, foreign policy issues that give special barter arrangements to political allies, such as the exchange of sugar and oil at nonmarket prices between Cuba and the Soviet Union; balance of payments considerations; ecology requirements; human welfare priorities, given the fact that food for most poor people in every country represents from 30% to 70% of their consumption expenditures; and, finally, the social structure of life—developing insulated policies for domestic commodity prices and protection to maintain small-scale farming agriculture as part of a way of life, and developing methods of reaching the small-scale producer in all countries without penalizing commercial producers who supply two-thirds of the world's food.

Historically, multinational enterprises in the food system sprawl across national boundaries filling a void in the vertical food system from farm supplier to ultimate consumer and carrying on those functions of input technology, farming, grading, assembly, storage, processing, and distribution that either are not performed at all or ineffectively performed by others in the total vertical food system we call "agribusiness" (Goldberg 1968). The fact that these entities have direct ownership of assets

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or relations with other entities across national boundaries may seem to be a threat to nations, especially in the sensitive area of agribusiness that encompasses some 60% of the world's population. In the past, some multinational entities were so eager to develop and manage a total vertical commodity system with the help and encouragement of local governments that they soon accounted for enormous percentages of a nation's gross national product (GNP) and exports—and when measured by size alone, were considered to be too powerful when compared to the small national-states in which they operated. Under these conditions, some firms had their assets expropriated, were asked to leave the country, but yet were asked to stay on in advisory capacities and to help manage and develop the potential export sales produced by their previously owned companies.

This paper will not dwell on the past activities of multinational entities but rather will stress the current and future roles multinational firms can play in global agribusiness trade and development.

Theory of Foreign Direct Investment of Multinational Entities

Researchers at Harvard Business School have developed one theory of the growth of foreign investment. Wells notes that "much of the theory of foreign direct investment starts from the assumption that certain firms have some sort of special assets that give them a competitive edge abroad. Various theories take different approaches to determine which firms are likely to have exploitable assets and whether they are likely to exploit those assets abroad through direct investment or by selling them to an enterprise in a foreign country.

"For a decade or so, attention has focused on the nature of the assets that might make a firm competitive abroad. The product life cycle theory proposes one model. According to its premises, firms innovate for their home market, generating skills and knowledge that, in some cases, are then exploitable abroad. Since managers are responsive to their home markets, the nature of a particular firm's advantage is influenced by the characteristics of that firm's national market. Given the nature of the U.S. market, U.S. firms are particularly likely to generate high income and labor-saving products or processes. As incomes and labor costs increase outside the United States, the skills acquired at home by U.S. firms turn into assets that can be exploited elsewhere. The peculiar nature of the U.S. market, as a bellwether of other markets, had led to the particular vitality of U.S.-based multinationals, according to the theory" (Wells 1979, p. 4).

Theory Applied to Multinational Agribusiness Corporations

The agribusiness system has three levels of operation: macroenvironment and public policy; each commodity system in relation to its macroenvironment; and the firm, farmer, or governmental institution as discussed in specific terms of that entity in relation to the commodity system involved.

Agribusiness firms then, both within and between nations, not only have to develop skills and knowledge of the specific operational functions they perform but also have to develop coordinating roles that position them in both their national and international commodity system. They have to adapt their operational and technological skills and their coordinating skills to the level of development that currently exists within and between the nations in which they are involved. Commodity systems do not stop at national borders, and multinational corporations, irrespective of their national origins or their proprietary, cooperative, or governmental ownership, are simply responding to a need to be one type of coordinating link in a global food system. They may have unique corporate strategies for their firms, but these strategies have to be carried out in a manner that is responsive to the goals of the national food systems in which their firms operate. Individual multinational corporations transfer their leadership role on the learning curve of one food system to the system that most closely resembles their home market. In a sophisticated developed market, the infrastructure and the market rules of the game are set forth by strong governments. In an unsophisticated developing market, the multinational firm may have to provide part of the infrastructure and, with the local government's approval, provide a grading and pricing system, as well as the firm's operational and coordinating skills.

As one reviews examples of alternative roles of multinational entities in a global food

system, one must do so against (*a*) a framework of past, current, and future trends; (*b*) a statement of the issues that must be addressed; and (*c*) a recognition that in spite of the consolidation of decision points in most national food systems at every level in the vertical food chain, there is a renewed vigor in the number and strength of multinational entities involved in both the developed and developing country food systems. The magnitude of the internationalization of the world's food system and the strength of the multinational entities is an opportunity to review the kinds of positive and socially useful roles these entities may play. As Galbraith states: "The exercise of power is not a matter of choice but of necessity. It is true of the multinational corporation, and it is wholly and equally true of the large national corporation. . . . Multinational intrusion by the corporations of one country also forces reciprocal actions by those intruded upon. . . . The only reasonable defense of the multinational corporation is now the truth. That it has power must be conceded. The only desirable defense is to hold that such exercise of power is inevitable and, if subject to proper guidance and restraint, socially useful" (pp. 86–88).

The Setting

The internationalization of the world food system became evident in 1972 when the United States sold off its surpluses (now called reserves) and grain prices increased almost 300% with a worldwide production decrease of 3%. Volatile price swings for most commodities have continued and, coupled with volatile exchange and credit rates (Schuh), have had an impact on the kind, number, and structure of the multinational entities in the global food system. The United States and Canada have become the dominant surplus grain-producing area of the world. By the late 1970s the biggest deficit areas were Asia, Africa, and Eastern Europe, and new entrants from Japan and Europe became part of the U.S. grain export market and started to become part of the internal domestic grain system.

The greatest challenge in the world is in the efficient and equitable development of the underdeveloped world food economies. In simplistic terms, the developing countries with 70% of the world's population produce only 40% of the food, have only 30% of the world's income, and only 20% of the purchased agricultural inputs.

Most population growth will take place in developing societies, with three-fourths of the world population being in the present developing sector by 1985. Over half of the population is engaged in the world's food system (agribusiness). In addition, three-fourths of the 145 million farm families in the world are noncommercial (produce primarily for themselves) and have farms whose average size is 5 hectares (11 acres) or less. How to reach these subsistent producers and enable them to become part of a commercial food system is an important factor in our discussion of the role of the multinational firm in international agricultural trade and economic development. Adding to the food pressures of our expanding human population is the fact that, in addition to the 4.8 billion people in the world in 1985, we will also have by that year a livestock and poultry population of approximately 14.9 billion.

World Grain Production and Trade Situation 1980 and Projections

Two-thirds of the world's farmers produce about one-third of the world's grain on their subsistence farms in developing countries. Another third of total grain is produced by developed country exporters (with the United States alone producing 25% of the world's grain production on only 11½% of the acreage devoted to grain production). About one-fifth of the world's grain production is produced by developed-country importers, and the remaining 15% of the world grain is produced by the Soviet Union.

The concentration of grain production in selected countries naturally results in a concentration of grain trade. Total world grain exports increased from the 4% and 25 million tons in the late 1930s to 187 million tons in 1979–80, or 15% of grain utilization and about 13% of production. By the year 2000, grain exports will be close to 300 million tons, with the United States supplying almost two-thirds of those exports.

Because North America is the only significant surplus grain-producing area in the world, U.S. export policy is tied up with the development, export, and import policies of every nation. All U.S. agricultural exports, grain and nongrain, are forecasted to be $40

billion and over 160 million metric tons in the late 1979–1980 export year, providing the United States with a positive trade balance of $22.5 billion. At the same time, our imports are estimated to be at an all-time high of $17.5 billion, with the enormous responsibilities of providing market access for both developing and developed countries to the U.S. market. By 1990, of the estimated $100 billion of U.S. agricultural export sales, $50 billion will be to the middle to upper income developing countries. These numbers are most important when one realizes that many of the procurement decisions are being made by governmental entities, that flexible long-term contractual relations will become more important in our future trade policies, and individual multinational firm rules will change.

In the future, our relationships with both the developing world and centrally planned economies could become even more intertwined. As Leontief noted in *The Future in the World Economy*, as incomes and populations rise by the year 2000, world agricultural production should increase by three to four times the 1970s' level and per capita output should double. The average total growth rate for all developing regions was projected to be 5.3% per annum from 1970 to 2000 and 1.6% per annum for the developed world. By the year 2000, it is projected that one out of every four cultivated acres in the United States will be producing food for the developing world. As it is now, one out of every three cultivated acres in the U.S. is currently providing production for exports. Is it any wonder that farm cooperative multinational firms are emerging with such a major market affecting American agriculture? It is estimated that in 2000, one out of every two acres could be providing production for exports, with some of the remaining acreage being devoted to energy farming.

U.S. Response

The U.S. response to the agricultural economic development needs of the developing world historically has been a confused mixture of surplus disposal and aid programs: of unique export and import concessional sales and markets, rapidly expanding export sales and grain-trading quantity agreements in the 1970s, and of financial and technical support directly from the United States or through the World Bank, Overseas Private Investment Company, or through private groups such as the Latin American Agribusiness Development Co. (LAAD) or individual private and/or cooperative firms, and the encouragement of commodity agreements for sugar, wheat, and feed grains.

Impact on Multinational Firm Strategies

With the broad projected changes in world agricultural trade, the dramatic volume and dollar changes that occurred in the early 1970s, and product life cycle theory of foreign direct investment, what roles can we expect multinational corporations to play?

The Grain Traders

Multinational grain trading has its sourcing focus in North America. As American surpluses dwindled in the early 1970s, a buyer's market became a seller's market. This new market brought new entrants into the export market and brought the potential of increased profit for some exporters. New firms, such as Cook, became market share leaders in 1976, only to misjudge commodity export markets and end up selling out. Cook saw its profits deteriorate from $22 million in 1975–1976 to a loss of close to $81 million in 1977, with a subsequent sale of its grain and processing operations to Mitsui and Marubeni, Japanese multinationals, and to Gold Kist, an American farm cooperative. These sales were representative of new entrants into the grain-exporting business from the grain deficit areas of Southeast Asia and Europe.

Zen-Noh. One example is that of the Zen-Noh Company.[1] This Japanese Cooperative[2] represents in one commodity or another the five million farmers of Japan. Its selling and procurement functions amount to over $25 billion a year.

One long-term objective is to develop an international Agribusiness Cooperative Center for the mutual benefit of all farmers. More specifically, it has trading and development relations with cooperatives in developing and developed countries all over the world. Recently (fall of 1979) its decision to build a

[1] Many of the examples in the following sections are from Goldberg et al.

[2] Throughout this paper, farm cooperatives describes those created and managed by farmers, rather than "farm cooperatives" created by governments and managed as semipolitical institutions.

terminal grain elevator in the United States had added to its relationship with the U.S. farm economy.

Alfred C. Toepfer International. Intrade, a joint American-European Cooperative,[3] has entered into an agreement with Toepfer, a German holding company, to create a new agricultural commodity-trading company named Alfred C. Toepfer International. Although farmer cooperatives handled 40% of the U.S. grain domestically, they currently handle only 10% of all grain exports. Intrade hopes to get farmer cooperatives more directly involved in the export market, to pass trading profits back to their farmer members, to improve their competitive position, and to promote integration and development with farm cooperatives in both developing and developed countries. (20% of the world's population belongs to one or more cooperatives, which are becoming a major international force, see Craig.) Nevertheless, the cooperative-based Intrade will trade with all types of entities as well as cooperatives and source supplies from the least-cost nation, thus improving the efficiency of the system and providing direct competition with proprietary multinational corporations. Like Zen-Noh, they will also engage in improving and helping the infrastructure and operations of developing country trading partners, be they sellers or buyers.

Japanese Trading Firms. The Japanese multinational proprietary corporations play a significant role in the Japanese mixed feed industry and work closely with the Japanese government. One creative activity of Japanese multinational firms is the development of both an external and internal market system, through a Japanese-Thailand Corn Agreement existing since 1961, which provides a mutuality of interest for both the Thai corn system and the Japanese feed industry. The existence of the agreement, and an assured market access for Thailand during a period of global corn surplus, provided a market incentive that led to a more than threefold expansion of Thai corn production during this period (with occasional declines due to unusually adverse weather conditions). Not only was production increased but, because the agreement was tied to the price of the nearest trading month for corn on the Chicago Board of Trade, price discovery in terms of a published and broadcast price was more readily available to producers.

In essence, commodity trading firms do not just buy cheap and sell dear, but rather recognize that they are an integral part of the food policies of the countries in which they operate and help, in cooperation with the government, to improve the efficient handling of the commodity through equitable agreements that, in turn, provide a price stimulus for local developing and developed country producers. The firms involved are heterogenous, and thus they can have an on-farm or off-farm orientation, a producing or consuming country orientation or a developed or developing country home of origin. In a sense, the internationalization of the world's food system has created an awareness in all the participants that they can create a multitude of international arrangements to be part of that system. In the early steps of development, with backward and forward coordination taking place, an increase in the number of participants directly active in the global food system provides a broad competitive market. One must be on the alert for the next stage of development, which may lead to new types of consolidation requiring new global, regional, and national market rules and regulations. At the same time, these new entities recognize that it is not enough to be just the most efficient operator, one has to be the most innovative in responding to the equity needs of the exploding developing country markets and involve the small-scale producer in the process.

Foreign Investors from the Third World

One interesting development concerning the current and future role of the multinational firm is the increasing number of such firms with origins in developing countries. Professor Louis T. Wells, Jr., of the Harvard Business School faculty, is a leading authority in this area. Much of the following discussion is based on five of his recent publications. Wells indicates that approximately 1,100 foreign-owned projects in less developed countries have thus far been identified as having parents in other developing countries. These projects represent only a fraction of such investments, since they are generally understated in official

[3] The partners include from America: Gold Kist, Land O'Lakes, Agway, Indiana Farm Bureau, Land Mark and Citrus World. The non-Americans include United Cooperatives of Ontario (UCO), Canada; CEBECO-HANDELSTAAD, Netherlands, Deutsche Raiffeisen-Warenzentrale Gesellenschaft (DRWZ), Germany; Cetreide Import Gesellenschaft (GIE), Germany; and Union Nationale des Cooperatives Agricole De Crex Cereales (UNCAC), France.

documents. As in the case of farmer cooperative multinational activity, their growth rate is much faster than that of their competitors who happen to be proprietary corporations.

These developing country multinational firms seem to be uniquely well-positioned to have an advantage in the following areas: (*a*) the creation of small-scale technology as a by-product of Western technology adapted to developing country conditions and to the need to use more labor-intensive technology; (*b*) the ability to create flexible processing operations that can produce multiproducts and multimodels for the internal small-scale markets of most developing countries; (*c*) the ability to modify operations to use local raw materials of less sophisticated quality to avoid external sourcing problems; (*d*) the ability to move from one developing country to another to avoid quotas on exports, e.g., quota hopping; (*e*) the ability to seek out countries that provide access to restricted markets, e.g., investments in Mauritius to gain access to the EEC; (*f*) the ability to develop (as do their advanced country competitors) vertical integration arrangements when long-term contracts break down because of unusually volatile markets; and (*g*) the ability to integrate forward into developed country markets by acquiring not only the value added and market distribution network but also branded franchises, such as the Brazilian Cooperative purchase of Hills Bros. Coffee in the United States.

Wells also points out that in spite of some well-publicized foreign projects undertaken by state-owned firms from the developing countries, a vast majority of the investments emanate from privately owned companies. In fact, as a matter of public policy, farmer cooperatives have been encouraged by national governments to play a more active role in the global food system so that producers may have a more important part in these systems. It would seem that public policy also will encourage developing country multinational firms to expand because of their special awareness of the problems of scale and of underutilization of labor as well as their contributions to an even more competitive global food environment.

Multinationals and Government Joint-Venture Changemakers

Just as there are leading changemakers at the indigenous and producer level, so there are unique multinational changemakers who are providing a much needed leadership in developing-country food systems. Two such changemakers are Tate & Lyle and Booker McConnell, Ltd. Tate & Lyle represents the evolution of a sugar firm that has moved from reacting to local governmental programs to actively trying to anticipate changes and provide collaborative leadership to the local private and public decisionmakers in the food system. Its goal has been to create national companies run by local nationals but with strong bonds to the Tate & Lyle group.

One of the best examples of a similar agribusiness approach is Booker Agriculture International Ltd. and its Mumias sugar scheme in Kenya. Even the severest critics of agribusiness applaud Booker's approach in the Mumias project and consider it one of the most important ways multinational corporations in agribusiness can make contributions to developing food economies. As Susan George states in her book, *How the Other Half Dies*, "In another sense, the success of Mumias is a further argument that multinational agribusiness must be controlled, for when it is, it has a definite contribution to make. . . . it appears to be an excellent specimen of the contributions business *could* make to development if *social goals*, not merely profitability, were present in the project from the drawing board to the actual operation" (pp. 182–5).

Such is the case of Mumias, which originated with the Kenyan Government requesting help and input from Booker on the project. Booker carried out a pilot project and, with the government, outlined a program to create a whole sugar system involving over 16,000 small-scale producers and 2,500 other employees, on a managing agency basis that compensates the company for productivity and efficiency.

Multinationals Improving the Infrastructure

Just as C. Itoh acted as a catalyst in the development of the Thailand corn economy through the Japanese-Thai Corn Agreement, other multinational firms have improved the food systems of their host countries through their operations in various foreign environments. One example is the case of Rafhan Maize, a CPC International joint venture in Pakistan. This company was formed to help in the expansion of a local corn-processing industry. In order to expand the industry, Rafhan Maize at

the government's request helped to provide an extension service to the local corn producers. They improved the corn technology of many farmers by providing a local market, guaranteeing a minimum price for corn (even before it was planted), and provided credit, seed, fertilizer, and storage. In many cases, the new varieties of corn provided two crops where only one has been grown previously. Rafhan also provided a grading system where none existed before. The processing industry provided local oil and starch products, which had been imported previously.

Private Development Groups—Latin American Agribusiness Development Corporation

LAAD is a profit-oriented private investment and development company. Incorporated in Panama in early 1970, the corporation develops and finances modest-sized private ventures in the fields of agriculture, animal husbandry, forestry, and financial services in Central and South America and the Caribbean. It helps develop local entrepreneurs to improve local food systems.

New Arrangements

Agribusiness multinational corporations bring not only their unique production, procurement, processing, marketing, financial, and managerial skills to other nations, but they have been able to transfer the coordinating skills and arrangements from one environment and adapt them to another. One example is the Foods Division of The Coca Cola Company, which developed a unique arrangement with a Florida cooperative (Florida Orange Marketeers) so that the cooperative supplied the oranges, the Minute Maid Company of the Foods Division and the cooperative shared profits based on processing and marketing, and the ultimate distribution, advertising, and promotion was left to the corporation. In Brazil, the Foods Division of The Coca Cola Company has a similar arrangement with local orange growers who operate the raw material procurement operation; the growers and the company jointly share in the packaging operations and the marketing is the function of the multinational corporation.

New Entrants

Because of the worldwide energy crisis and its impact on trade gaps, a new player will probably become more important in global agribusiness: the multinational oil company. In view of their financial surpluses, the oil companies have to consider what investments in addition to reinvesting in fossil energy might be appropriate for their firms. Given that they now see the potential of ethanol and biomass energy, as well as the fact that they handle commodities, have a logistic system, and work with both developed and developing countries, it would be logical to assume that they would be prepared to invest in global agribusiness.

Financial Implications

Finally there are major financial problems that require multinational corporate aid in the development of new financial instruments that are more flexible in their payout to reflect the continuing volatility of the global commodity-oriented food system. According to the World Bank, the 1980 total disbursement of capital is estimated to be \$70 billion, 1985 estimate \$122 billion, and 1990, \$184 billion. Private loans would represent about 40% of this flow. Compared to such inflows is a trade gap of the non-oil developing countries projected to be \$120 billion in 1990. Based on Mutsaers' estimate, if basic economic growth rates are to be realized, repayment of principal and interest payments by the developing countries would need to rise during the 1980s about five times and would bring the total deficit to be financed by 1990 to \$470 billion, of which medium- and long-term loans would need to provide \$320 billion (p. 1).

Conclusion

The global food system is in ferment. A heterogenous group of multinational entities are being created to respond to the market access, raw material procurement, appropriate technology, managerial, financial, logistical, risk management, and coordination needs of the many nations that make up our global food system. These entities recognize that they must perform their functions in ways that are responsive to an equitable pricing system for producers and consumers, that are performed in a manner that helps the subsistent producer and low income consumer become part of a commercial food system. So far, private and cooperative multinational firms have been most creative in structuring such entities. The traditional ownership patterns of control-

ling assets is changing to a management of complex relationships without automatic ownership of assets. The development of managers with a breadth of vision to perform their functions in a practical manner but with a responsiveness to the economic, political, and social priorities of the nations in which they operate is a primary responsibility of these firms. The role of the multinational corporation is to be but one alternative institution that coordinates a global food system. The fact that farm cooperative multinationals and developing country multinationals are increasing their market shares in the performance of the various functions of a global food system is encouraging evidence that at least for the present there is little to fear of domination by any one type of multinational entity. On the other hand, these entities, irrespective of ownership form and/or origin, are powerful and are also intelligent enough to heed Galbraith's advice that they be socially useful. The specific entities cited in this paper give evidence that there are many examples of the new breed of socially useful, as well as functionally practical, multinational corporations.

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The Role of Export Cropping in Less Developed Countries

Jimmye S. Hillman

Discussions about agricultural exports from poor countries (LDCs) often involve two diametrically opposed positions: those that view exports along with agribusiness and associated phenomena as causing most of the problems of poor countries; and those that believe not only in an export orientation for the less developed countries (LDCs), but that agricultural, raw material, and food exports hold a key place in the economic development of many of them. At the outset, I should like to recognize the danger of generalizing because of the diversity of LDCs. Developing countries vary greatly in size, resource endowments, economic and political systems, policies, and economic stability, for example. This means that many of the issues surrounding LDC exports, indeed all LDC trade policies, are empirical questions that require considerable research and frequently involve country-specific answers.

The term "export cropping" appears to be the latest etymological variation of a terminology which has been around quite a long time; viz, "monoculture," "cash cropping," and even that old colonial fallout, "commodity scheme." Export cropping is defined here as the pattern of specialization in production and distribution evolving out of comparative advantage and the capitalistic-oriented, development-trade model.

Is the recent criticism of export cropping just a rallying point for world food and hunger campaigns and the politics of food, and for the developmental processes necessary to obtain food? Or, do the critics of export cropping imply something more fundamental about traditional economic and social organization, human actions, and values? My feeling is that it is the latter. In any event, it appears that the current interest in export cropping has been accentuated by the increasingly intense interest in food and nutrition. Titles such as *Food First, How the Other Half Dies, Feeding the Few, Diet for a Small Planet, Bread for the World,* and *Overcoming World Hunger* have generated a great amount of interest in food and development problems. Much of the literature critical of export cropping is highly rhetorical and is characterized by general solutions and sweeping indictments. In *Food First* (Lappé and Collins), *How the Other Half Dies* and *Feeding the Few* (George), for example, the authors find fault with almost every development organization and imply that the entire social system needs change, particularly in the developed capitalistic countries.

The Presidential Commission on World Hunger pointed out that the major world hunger problem today is not famine or starvation, but the less dramatic one of chronic undernutrition. This view is corroborated by Seckler. Sloganeering and rhetoric about the impact of export-cropping policies should not obscure the need for programs to enhance agricultural production, rural employment, and nutritional improvement in the LDCs. My key point is that export policies must be part of these programs. It will be argued that production and trade policies centered around export-led growth make a positive difference for LDCs, because growth in incomes is the principal means of improvement in rural welfare, and exports provide an important means to generate income. The argument will be somewhat tempered by considerations of self-sufficiency and food security, and a recognition of the importance of trade liberalization by the developed world. Nor are these comments meant to detract from the importance of technological change and increased efficiency in production for the domestic market in the LDCs.

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Comparative Advantage

The notion of comparative advantage is the centerpiece of traditional trade theory and the principal rationale advanced by proponents of export cropping. The thrust of the theory is premised on the recognition that nations, or regions, are differentially endowed with resources, including human capital. These differences also extend to asset ownership, taste-endowment and related demand-creating attributes. Production and specialization, including the exploitation of economies of scale, lead to increased levels of world output, and exchange of this increased output represents the gains from trade.

Proponents of export cropping argue that by removal of the restricting assumptions of the traditional two-country, two-commodity model, the dynamic forces of trade promote and facilitate the complex processes of economic development and add important dividends, such as access to world food supplies. They argue further that trade encourages technological innovation and raises worker skills. Increases in the range of goods that can be purchased stimulates new wants and can create new areas of production or higher productivity. Only exports can enable low income nations to pay for those goods and services necessary for development but which they lack the capacity to produce. Finally, exports provide an important source of direct government revenue in many countries, as in Malaysia where, in recent years, 30% federal funding has derived from export taxes. Curtailing exports and trade would mean seriously undermining the fiscal positions of nations which are without alternative sources of taxes. In sum, trade, through the execution of the principle of comparative advantage, brings not only static gains to a country but also acts as a stimulus to growth.

Table 1 presents some data from the Food and Agriculture Organization (FAO) which demonstrate the practical logic of comparative advantage. These figures purport to show that LDCs would experience a foreign exchange loss (and farmers a loss in gross and net revenues) if they switch land out of traditional export crops into domestic production of food crops at present imported. Such figures, though used here to suggest a basis for specialization and trade, can provide only crude generalizations because they assume static technology, do not take into account

Table 1. Foreign Exchange Value of Selected Crops to Developing Countries

	Export Unit Values per Hectare (US$)[a]	
	1963	1975
Coffee	320	769
Cocoa	127	436
Tea	1,001	1,197
Tobacco	719	1,250
Sugar	352	1,462[b]
	Import Unit Values per Hectare (US$)[c]	
Wheat	73	210
Rice	83	283
Barley	48	145
Maize	58	169

Source: FAO trade and production yearbooks.
[a] Average export unit value multiplied by average yield in developing market.
[b] $1,462 in 1972–74.
[c] Average import unit value multiplied by average yield in developing market economies.

differential conditions of soil and climate for alternate crop use, ignore differences in input costs, and assume homogeneity of labor and static employment conditions. Nevertheless, the differences in the above qualifications would have to be very large indeed to overcome the substantial differences in gross revenues evidenced in table 1.

Table 1 also indicates rather substantial increases in the prices of agricultural products, and this trend is confirmed by more aggregate data. Furthermore, during the 1960s and 1970s there appeared to be little, if any, deterioration in the average terms of trade between agricultural and manufactured products. The World Bank price index for manufactured goods imported by LDCs increased by 246% between 1961–78. The FAO price index of LDC agricultural exports increased by 280%, while the price index of food imports increased by 250%. Thus, there appears little basis to suggest that countries have much to gain by diminishing their levels of agricultural exports.

Such figures, even if they provide a broad indication of the imprudence of shifting into food and out of export crops do not necessarily provide a basis for recommending further concentration on export cropping. Such caution has been neatly summarized by Lewis in a brief commentary on the factoral terms of trade as between the tropics and temperate zones (1978, pp. 14–20). He argues that the

tropical countries cannot benefit much from productivity increases in export commodities because of inelastic demand. Instead they must raise tropical productivity in the commodity common to all countries, domestic foodstuffs.

Given the prominence of food crops in the agricultural sector of most LDCs and the limited potential increases for most agricultural exports, the brightest prospects for growth may well lie with domestic food crops. But the key issue for LDCs will involve their ability to develop new varieties and technologies that will increase factor productivity sufficiently to induce comparative advantage and thus make food crop production economically attractive to farmers without major government subsidies. Research and development expenditure in tropical agriculture traditionally has been oriented toward export crops, while many of the prominent food crops—maize, millet, sorghum, cassava (manioc), yams, beans—have received little attention. Even for commodities which have benefited from research investment in recent years, such as rice and wheat, substantial potential remains. The potential for rainfed rice, for example, which comprises over 30% of Asian production, has yet to be intensively researched (Barker and Herdt). In addition to the development of improved varieties, increased productivity in food crops frequently will require new input technologies which make use of simple mechanical inputs to substitute for labor. While the potential for increased productivity may be unknown, it is clear that without major increases in research and development expenditures little improvement can be expected.

Instability of prices and the resultant erratic earnings from export crops present further problems for LDCs. There is substantial truth to the proposition that relatively low, short-run elasticities of supply and demand for the export crops of LDCs result in significant price instability. But government policies in the countries themselves contribute significantly to that instability. Some research on the subject shows, however, that while price instability imposes costs through its effects upon the allocation of resources, it is not obvious that it has been the LDCs that have lost from the income transfers brought about by convulsions such as the upsurge in agricultural prices after mid-1972 (Johnson 1978, p. 198). Other research on uncertainty provides grist for those who are unwilling to follow the pure theory of comparative advantage to its logical conclusion.

Problems in LDCs related to those particular crops whose prices are low and declining in real terms and to slow market growth and declining purchasing power are more intractable than the problem of price instability.

A number of studies using varying methodologies have attempted to analyze comparative advantage empirically. One such study analyzes a small, open economy—Senegal—under the assumption of aversion of economic policy makers to international price risk (Jabara and Thompson). The results show that a country may, indeed, be better off in a more diversified position than by taking the route of traditional comparative advantage. That is, under assumptions which include international price risk, a policy of free, undistorted trade may not be the first best policy for all small countries to follow. The authors of this study admit, however, that such programs should be consistent with a broader concept of comparative advantage which recognizes that risk has a subjective cost.

Another study of Senegal comes to somewhat different conclusions, more explicitly favorable to comparative advantage and export cropping (Pearson, Humphreys, Monke). The analysis shows that domestic production requires an average subsidy of 67% of c.i.f. prices, and that if the government desired protection against fluctuations in c.i.f. prices, a financial buffer fund is clearly more efficient than a domestic production subsidy. Only if rice were unavailable on the world market at any price does the alternative of domestic production, or diversification in food production, appear economically rational. Furthermore, the argument goes, domestic production itself is not free from uncertainty.

Self-Sufficiency in Food?

If comparative advantage is the centrifugal economic force propelling developing countries into the export world, then self-sufficiency in food would appear to be the centripetal political force which is drawing those countries inward for domestic solutions to their development problems. Self-sufficiency in food is viewed by many countries as the only alternative to export cropping and comparative advantage, and they place it at the

heart of their national development and their food and agricultural policies.

Provisional self-sufficiency estimates by FAO (1975) presented in table 2 for 103 countries (only 5% of the world population was not included) show that 3 billion of the world's population of 3.7 billion at that time lived in countries, each of which was at least 95% self-sufficient in kilocalories (O'Hagan). Somewhat unexpectedly, developed countries were less self-sufficient than developing countries, a fact which should not be lost on the export-cropping critics. Admittedly, the statistics presented in table 2 provide only part of the picture.

The current emphasis on self-sufficiency for food in developing countries is reminiscent of the rush toward import substitution of manufactures in the 1950s and 1960s. The most frequently articulated reasons for self-sufficiency involve conservation of scarce foreign exchange, protection of an economy against instability arising from fluctuating import prices, and insulation of a country from presumed political vulnerability associated with dependence on imports. Self-sufficiency, in short, often tempers comparative advantage because governments are responding to uncertainty in food supplies, depleted foreign exchange reserves, and poor income distribution with measures of direct intervention.

The North-South Commission, for example, suggests that in a broad perspective, self-sufficiency in food must be the aim of the world's major regions (North-South Commission, p. 93). This and other works emphasize that the concept of self-sufficiency in food is an optimum development strategy for developing countries (FAO 1975, 1979; O'Hagan).

Demands for self-sufficiency rarely address the appropriate degree of self-sufficiency, nor do they consider the costs involved in attaining self-sufficiency. But these factors are frequently the crux of the matter. Large-scale subsidization of agriculture is an expensive business for a country with 50% or more of its labor force on farms. Also, production costs in farming can rise rapidly when output is stimulated in regions badly suited to such farming. Variability in output can be more severe when self-sufficiency levels are higher than warranted by natural resource endowments. Moreover, imports of production inputs and investment goods for agriculture can put almost as much strain on the payments position as would importing the foodstuff itself. Despite self-sufficiency and export-cropping rhetoric and genuine aspirations, these factors suggest that a continued expansion in the absolute level of food imports by developing countries might be required due to the constraints on domestic budgets (Josling).

In conclusion, whether more or less self-sufficiency is desirable becomes an empirical question for each country, demanding more objective analysis. First of all, the costs of a self-sufficiency policy must be given more emphasis. Achieving improvements in income distribution involves both income sacrifices and transfers from urban consumers through higher food prices—thus, the urban poor suffer. While government policy discriminates against food production in some countries by taxation of inputs and outputs, it is question-

Table 2. National Food Self-Sufficiency, 1970–72

	Food Surplus Countries (Over 105% Self-Sufficient)	Approximately Self-Sufficient Countries (95%–105% Self-Sufficient)	Food Deficit Countries (Under 95% Self-Sufficient)
Developed countries			
Number of countries	11	7	8
Percentage of country group population	33	38	29
Developing countries			
Number of countries	22	25	30
Percentage of country group population	14	72	14
Total countries covered			
Number of countries	33	50	38
Percentage of population	19	62	19

Source: Adapted from FAO (1975). Self-sufficiency measured in terms of kilocalories.

able whether strong policies of self-sufficiency can be pushed in most countries before effective research and development programs are established for domestic food production and distribution. On the other hand, it must also be noted that current export levels in many developing countries do not reflect free trade, and distorted policies may in some cases overemphasize exports (e.g., by subsidies) or restrain export development (e.g., by export tax schemes).

Export-Led Growth

A policy of export-led growth in developing nations—including agricultural commodities—is closely tied in with global economic trends. Trade in agricultural goods is inevitably linked with trade in nonagricultural goods; thus, the market for agricultural products of developing countries is inextricably linked to the world market for their manufacturing products. World industrial production grew at an average rate of just under 6% and world agricultural output at a rate of just under 5% during the period 1953–73. These were double the rates of the four decades just prior to World War I. World trade, along with agricultural trade, jumped in a similar way. Total exports of the developing countries rose by nearly 7% per year between 1960 and 1973, or faster than the annual growth rate of their gross national product (Lewis 1979). Manufacturing exports from developing countries increased even more rapidly during that period—at more than twice the rate of gross national product (GNP). Thus, export-oriented policies of developing countries, buttressed by high growth rates in the industrial nations and major trade liberalization in those nations prior to 1974, were generally successful.

A variety of studies have demonstrated that growth performance has been more satisfactory under export promotion strategies than under import substitution strategies. Krueger concluded that countries which adopt an export-oriented trade strategy generally have experienced rapid growth of traditional exports, but even more rapid growth of nontraditional exports. The relationship between export performance and growth has been tested by the experience of many countries for (*a*) rates of growth of real GNP and of exports, (*b*) real GNP net of exports and exports, and (*c*) for rates of growth of GNP as a function of rate of capital formation, aid receipts, and export growth. Detailed studies at the national level, both for different time periods in the same country (for example, the Philippines and Turkey) and of countries (for example, on the positive side: Brazil, Colombia, Ivory Coast, Korea, Malaysia and Taiwan; on the negative side: Argentina, Egypt and India) provide further support for the strong link between export performance and growth rates.

Why such a difference in growth performance under export promotion strategies as contrasted to import substitution? Krueger (p. 288–92) and the studies she reviews point out (*a*) that technological-economic factors imply an overwhelming superiority for development through export promotion; (*b*) that differences in growth rates have often resulted, not from the choice of trade strategy as such, but rather from excesses in the ways in which import substitution policies were administered; and (*c*) that policies adopted in pursuit of an export promotion strategy are far closer to an optimum than are those adopted under import substitution.

How to come by increased efficiency and development in a developing country's agriculture is the problem which concerns both export croppers and those interested in food self-sufficiency. Johnson (1980) has given a general policy recipe which stipulates (*a*) adequate incentives for farmers through prices of products and imports that have a reasonable relationship to the real alternative values in the international market; (*b*) the development and availability of useful technology that will make possible higher levels of productivity of agricultural resources, both from land and labor; (*c*) adequate and reliable supplies of modern inputs for farmers; (*d*) access to national and international markets for farmers; (*e*) a significant improvement and expansion of irrigation; and (*f*) economic, political, and social systems which permit the farm population to share in economic growth. The importance of the latter factor, equity, has been emphasized by Schuh, who asserts that farm and rural people in developed countries are poor and inefficient because their governments have seriously underinvested in them, particularly in terms of health and education. Instead, governments have followed inappropriate policies which keep farm prices low by decree and which intervene in product markets to correct problems rooted in factor markets.

Ultimately, food security is one of the real reasons countries turn toward self-sufficiency schemes rather than let comparative advantage and free trade run their course. In Egypt, for example, like many developing countries, the major policy issue is whether to strive for self-sufficiency or rely on international trade for food. Egyptian policy currently favors the latter. A popular definition of food security in Egypt is to strive for a balanced agricultural trade—to have cotton and other agricultural exports pay for the imports of food. (MASI-GROUP).

Hence, a policy of export-led growth, in addition to dealing with problems of increasing productivity, employment, and equity in the agricultural sector, also must deal with the problems of economic uncertainty and the instability in food supplies. The principal controversy surrounding food security relates primarily to man's policy role, not to the limitations of man and nature to produce enough food. Export-cropping critics point to the world's physical resources and man's technical skills and imply that for people to go hungry is not a scourge but a scandal. Man is to blame; the system must be changed. Others, looking at the same situation, say, indeed, man is to blame, but it is man the political manipulator who intervenes in the production and distribution system, and not man the farmer, or scientist, or extension worker, or food distributor. Experience and evidence tend to substantiate the latter view.

In historical perspective, food security has increased because of economic development and the resultant international distribution processes. Various studies have shown that world economic growth and associated technological changes have greatly increased food security over the past century. Dramatic changes in communication and transportation, coupled with enlightened social attitudes toward the alleviation of starvation and hunger, have combined to assure access to food supplies for most communities and regions. An apparent reduction in the variability of world grain production, along with increased per capita incomes for much of the world's population, have combined to give them access to food reserves through trade and have added to world food security.

Trade Liberalization

Before proceeding to specifics about trade liberalization, it is necessary to emphasize that our scenario for export-led growth of LDCs is linked by trade to the speed of growth in the developed countries (DCs). In primary commodities, the relationship has been close for a long time (Lewis 1979, p. 9). The terms of trade also fluctuate with the growth rate of DCs within the limits permitted by the high elasticity of supply of tropical raw materials and by the link between agricultural materials and the price of grains. Since World War II there has emerged a new trade linkage involving exports of manufactures from LDCs to DCs, which depends on the rate of growth in the DCs, not merely because the growth affects consumer demand, but also because it influences the willingness of governments in the industrialized world to allow such imports to enter. Many LDCs have found that the effect of these links is multiplied by the further link between prosperity in their export trades and industrialization for their domestic market. Growth in the industrialized world is, therefore, a necessary condition to induce increased exports from the LDCs, but there must be trade liberalization as well, especially decreased barriers to exports of manufactures from the LDCs to the DCs. Given the demonstrated links between growth and trade, what the LDCs need is (*a*) that the industrialized world should grow as fast as possible, and (*b*) that it lowers its protection against goods from LDCs, especially against processed agricultural products and manufactures.

A large number of products are subject to trade barriers from industrial countries, which result from a desire to protect their own domestic production. Conclusions from a recent study undertaken for FAO (Valdes) are in general accord with several other studies which examine the impact of agricultural protection. That study concludes that a 50% reduction in the protection given to food and processed food and feed commodities in OECD countries would lead to a $3 billion increase in the annual exports of the fifty-seven most populous developing countries. Such an increase would amount to approximately 15% of total exports of the seventy-nine commodities included in the analysis. Furthermore, full trade liberalization in the commodities would about double the gains.

The potential gross benefit to the fifty-seven developing countries from a 50% reduction in protection—expressed in annual flows for the main products concerned—are shown in table 3. Sugar, beef and veal, and wine account for two-thirds of the overall increase, whereas

Table 3. Potential Foreign Exchange Benefits to Fifty-Seven Developing Countries from 50% Reduction of Protection in OECD Countries

Commodity	Increase in Value of Exports[a]	Percentage Increase in Value
	------ ($million) ------	
Raw sugar	659.0	22.6
Beef and veal	590.8	58.7
Wine	495.2	76.7
Refined sugar	222.1	134.4
Green coffee	136.0	2.7
Maize	82.2	7.5
Cocoa butter oil	61.1	24.1
Wheat	57.9	19.1
Pig meat	53.2	339.7
Tea	49.0	4.8
Molasses	42.6	20.6
Olive oil	38.0	19.7
Groundnut oil	31.6	11.8
Cocoa beans	31.8	2.1
Citrus juice	30.5	35.6
Coconut oil	27.9	8.2
Palm oil	24.7	4.7
Cassava	21.9	3.6
Soy cake	21.6	7.1
Groundnut cake	19.3	7.5
Bananas	18.2	4.2
Barley	16.3	78.2
Coffee extracts, etc.	16.2	8.9
Oranges	15.7	6.5

Source: Valdes.
[a] Valued in 1977 prices.

coffee, cocoa, tea, and bananas combined would amount to less than 10%.

The study by Valdes estimates that even larger benefits could be achieved through increased processing of agricultural raw materials in developing countries before export. If natural rubber, cotton, jute, hides and skins, and timber, at present exported in primary form, underwent intermediate processing in developing countries before export, their gross foreign exchange earnings could at least double from $6.7 billion to $13.5 billion, based on 1975 figures. Moreover, if the processing of rubber and cotton could be undertaken to a second stage of manufacturing, additional export gains of $4.6 billion could be achieved.

Trade liberalization relative to the agricultural products and raw materials (including processing) above may not be sufficient to achieve gains of these magnitudes, nor everything hoped for by LDCs. There is no doubt, however, that restrictions on trade in processed agricultural products, through the use of tariff escalation and nontariff barriers, constitute a major limit to faster growth in the export of these products from developing countries.

While exports of primary commodities will continue to be important for the LDCs, the export of manufactures constitutes a more important element for many poor nations' economic development. Thus, is emphasized the great importance of liberal trade policy as a complement to the rapid growth policies in industrial countries in order to increase economic well-being in the LDCs. In this regard, the results of the Multilateral Trade Negotiations (MTN), concluded in 1979, were disappointing. During the past fifteen years the main center of debate on economic development, as far as trade is concerned, was transferred from the General Agreement on Tariffs and Trade (GATT) to the United Nations Conference on Trade and Development (UNCTAD). Except for preference schemes for manufactured products from LDCs, the Tokyo Round of GATT negotiations were not formulated very differently than those of the Kennedy Round insofar as LDCs were concerned. GATT missed the opportunity during those years to accept principles along the lines which would have accorded free entry to imports from LDCs at an early date as an advance installment, so to speak, of the eventual achievement of the general elimination of tariffs, which in theory should be the logical outcome of future rounds of tariff negotiations.

Unfortunately, the glamor which was attached to the ideas of "preferential treatment" in the quatrennial UNCTAD debates swamped the strength of the free entry and eventual tariff elimination arguments. The "generalized preference schemes" (GSP) which have emerged suffer from many defects. Most schemes are quite substantially circumscribed in scope, and in almost all cases incorporate exceptions and mechanisms of safeguards and control. These exceptions and safeguards are of such nature to lend credence to the charge that they are designed to make sure that competition can be cut off or at least deprived of any encouragement as soon as it threatens to become effective or significant. Such treatment, including time limitations for GSP treatment—such as the ten-year period incorporated in U.S. legislation (U.S. Trade Act of 1974)—also substantiate accusations relative to uncertainty and instability attached to imports from LDCs. In short, LDCs have

much more to gain from multilateral tariff reductions than from maintaining preferential margins, on which UNCTAD efforts have concentrated in recent years. This is because tariff reductions do not involve quantitative limitations on trade and are not reversible, while imports under preferences are subject to quotas and can be revoked on short notice. Developing countries, as implied earlier, need a stable environment in which shifts in the international division of labor so necessary for their rapid economic growth can take place.

In addition to the question of preference margins and free entry, other areas of concern to LDCs were not dealt with adequately in the recently completed trade negotiations. Quantitative restrictions, especially those typified by the Multi-Fiber Arrangement (quota), lead the list. Specific exceptions that industrialized countries have made to the agreed tariff-cutting formula is another area of concern. Developing countries are also apprehensive about the "selectivity clause," which some industrial countries insisted upon being included in the proposed code on safeguards. Developing countries are also worried that the surveillance machinery and sanction powers remain too weak, because it could be the poorer members of the international community who would suffer from violations of the proposed codes of conduct agreed on at Geneva.

Concluding Remarks

Export-cropping critics are worried about many of the right symptoms of economic development, hunger, and nutrition problems. When compared with most organizations which have studied these problems in depth, however, they differ as to causes and cures. The principal benefit derived from literature critical of export cropping is the fact that it has forced the reexamination of methods and plans being used by traditional development organizations. Closer scrutiny has resulted in the correction of errors and better execution of programs.

That type of contribution, while generating interest in food and development problems, contributes little to their basic solution. Export-cropping critics appear to ignore or to turn their backs on empirical evidence that indicates the benefits derived from comparative advantage, trade, and export-led growth. They seem to ignore that along with the benefits of self-sufficiency policies there come substantial costs and risks. That is, variations in domestic food output are going to be high and the resulting price variability will be as vulnerable as that associated with export crops.

Finally, the simplistic and superficial rhetoric which surrounds the self-sufficiency-export controversy often ignores the great diversity of developing country problems. The literature is often not research-oriented, and in addition to its vague generalizations, commits the gross error of extrapolating the experiences of one country to the entire developing world. My suggestion is that the most extreme of the export-cropping critics redirect some of their energies to collecting and analyzing unbiased, representative, empirical data on specific problems for specific countries. I am confident that these data will demonstrate the big gains to be obtained through higher-valued exports and trade rather than reducing present exports by switching resources to agricultural self-sufficiency. It is only at the individual country level that solutions to the export-self-sufficiency controversy can be found.

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The Role of Land Reform in Economic Development: Policies and Politics

Alain de Janvry

As the extensive literature on the subject attests, the issue of land reform has been and remains heatedly debated.[1] The latest massive demonstration of interest came with the 1979 World Conference on Agrarian Reform and Rural Development, where representatives of no less than 145 nations and three liberation movements agreed that "equitable distribution and efficient use of land . . . are indispensable for rural development, for the mobilization of human resources, and for increased production for the alleviation of poverty" (FAO). At one time or another, but especially since 1960, virtually every country in the world has passed land reform laws. Yet, the record is far more modest than the premise: (*a*) in spite of decades, if not centuries (Tuma), of land reform activities, landownership remains extremely skewed, concentration of landownership is almost universally increasing, the mass of landless is growing rapidly, and the extent of rural poverty and malnutrition has reached horrendous proportions; and (*b*) in spite of widespread agreement on the need for land reform, there are virtually no significant ongoing land reform programs except under extreme political pressures (revolutionary in El Salvador and postrevolutionary in Nicaragua, Mozambique, and Angola). In several countries, the progressive gains achieved by land reform programs are being either eroded by the forces of economic growth (Mexico, Venezuela, and South Korea) or purposefully canceled by public policies (Chile).

The question I want to explore in this paper is: Why this blatant discrepancy between rhetoric and reality? Or, to put it another way, why is land reform no longer a significant policy issue even though it remains an important political issue in most countries of the world?[2] To answer, we need first to explore, in a positive sense, what has been the nature of different land reforms that occurred in the past; what were their purposes, achievements, and limits. This will be done by developing a typology of land reforms in the third world, because it is essential to distinguish carefully among a wide variety of reforms. Following the approach of political economy, I will do this in the context of modes of production, social class structure, and types of land tenure.

Using this typology, we can then characterize the nature of past land reforms and identify the needed character of future reforms, given the actual state of the agrarian structure. This gives us a basis from which to seek answers to the question as to why land reform appears to be a dead policy issue in most countries today.

By looking at the wide array of rationales and proposals for land reform, we can then identify a number of political stands on the expected role of land reform in the process of economic development. Because land reform is fundamentally a political issue that seeks to achieve or prevent social change, explicitation of the political expectations from reform for different groups permits us to order and clarify the massive number of arguments advanced on the subject.

Types of Land Reform

We need to start first with a few definitions because part of the difficulty with the debate on land reform comes from using different concepts under the same name.

A reform is an institutional innovation pro-

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[1] For Latin America only, see Land Tenure Center.

[2] I call policy the institutional changes implemented by the government in power while politics are institutional changes proposed by any social group—dominant or not.

moted by the ruling order in an attempt to overcome economic or political contradictions without changing the dominant social relations. Thus, reform falls short of revolution (where the dominant social relations are changed) and goes beyond mere disregard of economic problems or repression of political demands. While instituted within the ruling order, the origin of reform can, however, rest just as well in the political pressures of the dominated groups as in the initiative of the dominant classes. Land reform, in particular, aims at transforming the agrarian structure. The agrarian structure is characterized by a system of social relations (modes of production and their corresponding social class composition) and a system of land tenure (ownership and usufruct of land and water by farm sizes). Land reforms consequently can change the modes of production in agriculture (themselves dominated by an eventually different mode in society at large which cannot be altered by reforms), the class structure (and, consequently, control of the state by specific classes and their respective access to public goods and services), and the pattern of land tenure.

Use of the concepts of mode of production, social class, and land tenure thus allows us to characterize a variety of states of the agrarian structure. A land reform is then nothing else than an attempt by the government, through public policies, at either inducing a change among states of the agrarian structure or at preventing such a change. A typology of land reforms, consequently, can be usefully constructed as a matrix of changes/no changes among states of the agrarian structure. This is done in table 1 for the thirty-three most important land reforms in the world over the last seventy years.

For our purpose, we can distinguish between three modes of production in agriculture (semifeudal, capitalist, and socialist) and, under capitalism, three landed social classes (capitalist landed elites, farmers, and peasants).[3] This gives us five relevant initial states of the agrarian structure: semifeudal estates controlled by the traditional landed elite with bonded labor (debt peonage, rent in labor services, etc.) and extraeconomic forms of coer-

[3] There are, of course, other modes of production beyond the feudal which are not capitalist or socialist. This includes the Asiatic, Communal, and Lineage modes. Without much loss of generality for the purpose of this paper, I am subsuming all these other modes under the feudal heading.

Table 1. A Typology of Land Reforms

Pre-Land Reform			Post-Land Reform				
		Mode of Production in Whole Society	Capitalist				Socialist
		Mode of Production in Agriculture	Semifeudal	Capitalist			Socialist
		Land Tenure	Semifeudal Estates and Reform Sector	Capitalist Estates and Reform Sector	Capitalist Farms and Reform Sector	Peasant Farms	Socialist Farms
Capitalist	Semifeudal	Semifeudal estates	(1) Mexico, 1917–1934 Taiwan, 1949–1951 Colombia, 1961–1967 Chile, 1962–1967	(2) Bolivia, 1952– Venezuela, 1959– Philippines, 1963–1972 Ecuador, 1964– Peru, 1964–1969 Colombia, 1968–	(3) Mexico, 1934–1940 India, 1950– Guatemala, 1952–1954 Egypt, 1952–1966 Iran, 1962–1967 Chile, 1967–1973	(4) South Korea, 1950– Taiwan, 1951–1963 Iraq, 1958–	(5) China, 1949–1956
Capitalist	Capitalist	Capitalist estates	(6)	(7) Costa Rica, 1962–1976	(8) Peru, 1969–1975 Philippines, 1972–1979	(9)	(10) Cuba, 1959–1963 Algeria, 1961–1971
Capitalist	Capitalist	Capitalist farms	(11) Guatemala, 1954–	(12) Chile, 1973–	(13) Mexico, 1940– Dominican Republic, 1963– Egypt, 1961–	(14)	(15)
Capitalist	Capitalist	Peasant farms	(16)	(17)	(18)	(19)	(20)
Socialist	Socialist	Socialist farms	(21)	(22)	(23)	(24)	(25) Cuba, 1963– China, 1952– Algeria, 1971–1977

cion; capitalist estates controlled by the landed elite-turned-capitalist and using wage labor; capitalist farms and plantations whose owners, the farmers, share in the control of the state with the bourgeoisie-at-large and hire wage labor; peasant farms, ranging from family to subfamily (semiproletarian), where no labor is hired but some may be sold; and socialist farms, either family farms, labor cooperatives, or state farms, imbedded within a socialist mode of production in society at large.

The land reform itself creates a reform sector and transforms or not the agrarian structure into a set of other states. It is important here to distinguish between reform and nonreform sectors, even though most of the literature on land reform considers only the first. The reform sector is the set of farms which is created by expropriation of private lands, distribution of public lands, or colonization of new lands. It is usually organized in the form of family or collective/state farms. The nonreform sector includes the lands retained, subdivided, or sold privately by the former owners. As we will see, most land reforms have sought their economic results in the impact they had on the nonreform sector. After land reform, there are correspondingly five relevant states of the agrarian structure: three where the nonreform sector remains dominant and composed of either semifeudal estates, capitalist estates, or capitalist farms and two where the reform sector is dominant and sometimes exclusive—one under the capitalist mode of production and the other under the socialist mode.

Table 1 classifies thirty-three reforms in twenty countries. A particular country can reenter the matrix more than once if land reform programs are redefined over time, but it must always reenter it in the same state to which it was transformed by the previous land reform. Table 2 provides empirical evidence to support the classification of reforms in table 1 and to identify their respective achievements.

All the diagonal reforms are essentially redistributive reforms in the sense that they either increase the size of the reform sector without changing the nature of the nonreform sector (reform types 1, 7, and 13 in table 1) or redefine the nature of the reform sector (19 and 25). Reform 1 is redistributive within the semifeudal order. Typical examples are the early reforms in Taiwan (1949–51), Colombia (1961–67), and Chile (1962–67), where the main objective was to distribute to peasants empty public lands or lands abandoned by the landed elite without otherwise questioning the continued domination of semifeudal estates in the agrarian structure.

Reforms 2, 3, and 4 aim at liquidating feudal remnants from agriculture and at inducing a transition to capitalism under domination in agriculture of the landed elite (2), farmers (3), or peasants (4). These reforms, directed against feudalism principally during the 1960s, have been both the most prevalent and the most successful in their intents. Reforms that induce a transformation of semifeudal into capitalist estates (2) seek this result by prohibiting bonded labor and rents in labor services (Bolivia, Philippines 1963–72, Ecuador, and Peru 1964–69) and by imposing minimum productivity levels on land use (Venezuela and Colombia). This is obtained by threats of expropriation if these requirements are not met. The purpose of a reform sector, in this case, is more to demonstrate the seriousness of the threats and to satisfy peasants' clamors for land than to increase production. Land reforms (3) induce the reorganization of the nonreform sector into a system of capitalist farms by imposing ceilings on landownership in addition to prohibiting semifeudal social relations. Maximum farm size was thus restricted to 200 irrigated hectares in Mexico (1934–40), 50 in India, 42 in Egypt, 150 in Iran, and 80 in Chile. Here, again, expropriations and creation of a reform sector have mainly the political purpose of stabilization, while the economic gains of the reform are sought in the nonreform sector. The case of Mexico, with its remarkable political stability in spite of massive rural poverty and exceptional growth through the 1950s and 1960s obtained mainly in the nonreform sector, is the clearest illustration of the means and ends of this type of reform. Land reforms (4) are integral reforms in the sense that the nonreform sector is secondary or totally eliminated, and peasants acquire control of the land under the form of family farms (South Korea and Taiwan) or collective farms (Iraq). Taiwan and South Korea demonstrated the economic and political gains of integral reforms where family farms are effectively supported by external institutions that allow them to realize their full production potential.

Once the capitalist order has been established throughout agriculture, transition reforms are passé. The only possible reforms under capitalism in society at large are either shifts among types of agrarian structure (8, 9, and 14) or redistributive reforms within a

Table 2. Characteristics of Land Reform in Twenty Countries

Country	Land Reform Year (1)	Land Reform Type (2)	Land in Reform Sector (3)	Peasantry in Reform Sector (4)	Size of Reserve (5)	Form of Organization in Reform Sector (6)
			----- (%)	-----	(hectares)	
Mexico	1917–1934[a]	1[b]	6	11	100–200[c]	Subfamily/family
	1934–1940	3	13	26	100–200 *i*	Subfamily/family; collective
	1940–1976	13	25	18	100–200 *i*	Subfamily/family
Total	1917–1976		43	50		
Guatemala	1952–1954	3	34	33	90–200	Subfamily/family; cooperative
	1954–1969	11	5	3		
Bolivia	1952–1970	2	18	39	24–50,000	Subfamily/family
Venezuela	1959–1970	2	16	15	No limit	Subfamily/family
Colombia	1961–1968	1	[d]		No limit	Subfamily/family
	1968–1972	2			No limit	Subfamily/family
Total	1961–1972		10	4		
Chile	1962–1967	1	[e]	—	No limit	Subfamily/family
	1967–1970	3	9	6	80 *i*	Subfamily/family; cooperative
	1970–1973		31	14		Cooperative; collective
Total	1962–1973		40	20		
	1973–1975	12	9	4		Subfamily/family
Peru	1963–1969	2	3	7	845–12,675	Subfamily/family
	1969–1976	8	39	25	35–1,500	Cooperative; subfamily/family
Total	1963–1976		42	32		
Ecuador	1964–1969	2	1	4	No limit	Subfamily/family
Dominican Republic	1963–1969	13	2	2	No limit	Subfamily/family; cooperative
Cuba	1959–1963	10	59	64	402	Collective; family
	1963–	25	100	100	67	State farms; family
Costa Rica	1962–1976	7	10	4	none	Family; collective
Philippines	1963–1972	2	—	—	No limit	Family
	1972–	8	—	1	[f]	Subfamily/family
South Korea	1950–1969	4	69	66	3 *i*	Subfamily/family
Taiwan	1949–1951	1	11	20	No limit	Family
	1951–1963	4	16	24	3 *i*	Subfamily/family
Total	1949–1963		27	44		
Iraq	1958–1975	4	85	23	250 *i*	Cooperatives and state farms
Iran	1962–1967	3	31	19	20–150	Family
India	1950–1966	3	3	4	50	Subfamily/family
Egypt	1952–1961	3	7	4	84	Family
	1961–	13	8	5	42	Family
Total			15	9		
Algeria	1962–1971[a]	10[b]	28	10	none	Self-management and state
	1971–1977	25	40	16	none	Self-management and state
China	1949–1952	5	45	63	none	Small family farms
	1952–	25	100	100	none	People's communes

Sources: For a complete list of sources for columns 3–6, interested readers may write to the author.
[a] Initial year corresponds to year land reform law was passed. Final year corresponds to end of the program or final year for which data are available.
[b] See table 1.
[c] *i* denotes irrigated land.
[d] Blanks indicate no separate data provided.
[e] Dashes indicate less than 1%.
[f] Corn- and rice-tenanted land only.

given type of agrarian structure (7, 13, and 19). Historically, the most important type of reform in the first group has been that which transformed the nonreform sector from capitalist estates to capitalist farms (8). Its purpose is evidently to eliminate the landed elite from control of the state and thus achieve a more production-oriented agricultural policy

while creating a more competitive environment in agriculture. This was attempted in Peru by imposing a ceiling on landownership of 50 irrigated hectares on the coast and 30 in the Sierra. In the Philippines, the ceiling was 7 hectares on rice and corn land. With the agrarian structure dominated by capitalist farms, subsequent land reforms can only be redistributive (13) or integral (14). Expansion of the *ejido* sector in Mexico from 1940 to 1977 and expropriation of rice farms in the Dominican Republic are instances of redistributive reforms (13).

All reforms can, of course, give way to counterreforms. Chile thus recreated a landed elite after the military coup of 1973 by abolishing ceilings on landownership, and Guatemala restored semifeudal social relations in agriculture when the Arbenz government was overthrown by foreign armed intervention.

Land reforms that are part of a transition to socialism are evidently more than mere reforms since the mode of production dominant in society at large is transformed—a process which is, by definition, nonreformist (5, 10, 15, and 20). The Chinese land reform was part of a transition from feudal society, while the Cuban and Algerian land reforms originated in agrarian structures dominated by capitalist estates and plantations. Subsequent transformations of the agrarian structure in China, Cuba, and Algeria fall in the category of redistributive reform (25). For lack of space, we concentrate, in the rest of this paper, on land reforms achieved under continued domination of the capitalist order in society at large.

Land Reform as a Policy Issue

During the last seventy years, most land reforms under the capitalist order in society at large have been of either one of two broad types: antifeudal reforms seeking to induce in agriculture a transition to capitalism with the resulting agrarian structure dominated by a capitalist landed elite (reform type 2), a farmer class (3), or a free peasantry (4) and land reforms within capitalist agriculture seeking to create shifts in the dominant rural class from capitalist landed elite to farmers and to peasants (8, 9, and 14) or to amplify the reform sector under domination of either one of these three classes (7, 13, and 19).

Antifeudal Reforms

Reforms against feudal bonds and personalized coercion have originated in peasant rebellions since time immemorial, but they have led to transitions to capitalist agriculture in the third world only during the last fifty years, with the cases of Mexico and Bolivia as outstanding examples. Since the late 1950s, however, with the rise of surplus labor associated with demographic explosion and modernization of many landed estates, organization of rural labor markets with plentiful supplies has created a new rationality to oppose feudalism—this time on an economic instead of a purely political basis: labor relations in agriculture could be transformed from feudal, where labor is a fixed cost, to capitalist where labor becomes a variable cost adjusted to fluctuating weather, market, and technological opportunities. Antifeudal land reforms thus potentially could achieve at the same time equity gains in response to peasant pressures and efficiency gains in response to demands for cheap food originating among urban industrialists and consumers and for increased export earnings originating in the urban-industrial sector. This led to formation, in the 1960s, of broad coalitions of different factions of the bourgeois, peasant, and proletarian classes opposing the feudal landed elites under the banner of expropriation and redistribution of the land. In Latin America, this resulted in the 1961 Punta del Este Charter of the Organization of American States inducing essentially every country of the continent to pass antifeudal land reform laws.

For the dominant interests in this coalition, the objectives of land reform were to be sought in the combination of nonreform and reform sectors. The economic goal was to be obtained by fomenting the development of capitalism in the nonreform sector through a mix of threats of expropriation and inducements to investment (subsidized credit, infrastructure construction, new technological advances, extension services, etc.). The goal of political stabilization was sought by creating a reform sector of a size commensurate with peasant pressures. It is, consequently, only under the most extreme threats of destabilization, such as in Mexico but even more in South Korea and Taiwan, that the reform sector reached major proportions. The success of antifeudal reforms should, consequently, not be assessed in terms of the extensiveness of

expropriations (the publicized explicit goal) but in terms of development of capitalism and political stabilization, with actual expropriations serving only as a means of reaching these goals. In that sense, countries like Colombia, Ecuador, and India had successful antifeudal land reforms without virtually having any in a distributive sense.

In Latin America, the combination of spontaneous development of capitalism and antifeudal land reforms has virtually liquidated feudal remnants and, hence, put an end to this type of reform. The Green Revolution in food production and development of agroexport agriculture, in close connection with international agribusiness, have themselves served as effective surrogates or complements to antifeudal reforms (Arroyo). In most of Asia and the Middle East, similarly, feudal elites have given way to a capitalist elite and a farmer class. In Africa, rapid privatization of the land has also seriously undermined precapitalist forms of land use.

With the end of feudalism, future land reforms must, of necessity, occur within the capitalist order in agriculture. This requires markedly different coalitions and occurs in response to markedly different purposes.

Land Reforms within Capitalist Agriculture

Once agriculture is characterized by capitalist social relations, there are four important reasons why land reform becomes an unlikely policy issue. The first is that the political alliance which must be organized to support land reform will need to be capable of opposing the established capitalist interests in agriculture. This is evidently such a formidable undertaking that it usually will require extreme economic or political circumstances. Opposing the landed elite is difficult because it has strong control of the state apparatus; usually has diversified investments in industry, commerce, and finance that give it economic power beyond agriculture; and is closely allied with foreign capital. Opposing the farmer class is equally difficult since it demands that one fraction of the bourgeoisie oppose another and puts into question the inalienability of property rights. The result is that reforms in capitalist agriculture have only occurred under rather exceptional circumstances, such as government reaction to strong revolutionary pressures (Mexico 1940–77, and the Philippines 1972–75), military interventions in favor of the national bourgeoisie (Peru 1969–75), or external influences (Dominican Republic). Short of this, expropriation of one fraction of the bourgeoisie by another requires full compensation for the former landlords. This, in turn, depends upon availability of a large fiscal surplus or massive foreign aid. This is partly what happened in the Dominican Republic, where the state used the enormous urban and industrial assets confiscated from Trujillo and plentiful foreign aid to compensate fully the expropriated rice farmers. Seen in a historical perspective, however, strong public budgets are unlikely to characterize third world states.

The second reason land reforms in capitalist agriculture are an unlikely policy issue is that the former coincidence of efficiency and equity gains that characterized antifeudal reforms not only may have vanished with the development of capitalism in agriculture but may have given way to a trade-off between these two purposes of reform. With agriculture well advanced on the road to modernization in the context of medium- and large-scale capitalist farms and of a close integration with multinational agribusiness, any drastic land redistribution is likely to nullify past technological achievements and imply short falls in production, at least in the short run. Where the population is increasingly landless and urbanized, the social cost of higher food prices may be more widespread than the welfare gains of land redistribution. This does not mean, of course, that land reforms cannot be managed to avoid efficiency costs: organization of the reform sector on the basis of state or cooperative farms (Peru's sugar farms and the Dominican Republic's rice sector) and establishment of institutions strongly supportive of family farms (Taiwan and South Korea) have demonstrated feasible solutions. However, it does mean that the margin for successful management of reform in terms of production performance is substantially reduced by the very development of capitalism. Seen in this fashion, the Green Revolution and integration of third world agriculture with international agribusiness have both been effective surrogates for antifeudal land reforms and obstacles to subsequent progressive reforms.

A third reason land reforms in capitalist agriculture are unlikely policy issues is that most third world countries have opted for models of economic development where industrial growth is based on expansion of a market for exports or luxury consumption goods and not

principally of a market for wage goods. This implies that progressive income redistribution to create the home market for industry is not essential to avoid underconsumption crises. Like in Lewis' model of the dual economy, where the working class and peasants do not consume the products of the modern sector, income redistribution acts as a break on the rate of economic growth as it lowers the rate of profit. Income redistribution and, hence, land reforms are not economic needs for the system at large in creating the domestic market for the modern sector but political gains of the working class and peasants. For that reason, again, land reforms will only result from strong pressures that can question the existing social order.

A fourth and last difficulty with capitalist land-reform policies is that the bourgeoisie will respond to social pressures for land reform by conceding it for the sake of legitimation of the dominant social relations. Hence, land-reform programs are expected to be as limited as possible while achieving their political purpose. But any program of land reform tends to unleash redistributive expectations and to stimulate broad mobilization of peasants and workers. Limited land reforms are thus an instrument of both expected stabilization and potential destabilization. As Sorj observes for the case of Brazil, this implies that "any attempt at limited agrarian reform will be accompanied by the action of a repressive apparatus and by creation of corporativist bodies intended to keep the reform within the limits of the present structure of accumulation and domination" (p. 31). Faced with both the need to create social support in agriculture and the ambiguities of land reform for that purpose, most governments have turned, since the early 1970s, to the alternate strategy of integrated rural development. The political end is here the same: to create a supportive minority of upper peasants. But the instrument for that purpose need not threaten landownership because technological change becomes a substitute for land redistribution. The example of Colombia is here clear: In 1973, both liberal and conservative parties agreed to put an end to the destabilizing effects of limited land reform resulting, in particular, in continuing land invasions, while launching an ambitious program of integrated rural development with the support of international lending institutions. At the same time, agricultural growth was stimulated by generous public support to the large-scale capitalist sector.

In a postfeudal capitalist order, consequently, it is no surprise that so few land reform policies are being enacted or implemented. Yet, the symptoms of serious agrarian crises remain unabated: food deficits keep on increasing (IFPRI), and rural poverty keeps on worsening (ILO). For this reason, land reform remains an important political issue even if for a variety of different purposes according to contrasted political programs.

Land Reform as a Political Issue

A wide range of arguments has been advanced justifying the role of land reform in economic development, and it is the prevalence of these arguments that keeps land reform an active political issue. Some of these arguments have been advanced on technocratic grounds, while others have been openly couched in ideological terms. Yet, all land reform programs fit within some global view of the role of agriculture and peasants in economic development. These can be regrouped under four alternative political programs, each of which proposes land reform for sharply contrasted economic and political purposes.

Land Reform for Social Status Quo: The Conservative Model

With capitalism well entrenched in agriculture and the performance of agriculture fundamentally determined by market incentives and public and supporting institutions (infrastructure, technology, credit, etc.), the conservative model allows for land reform only as a minimal concession for political stabilization. Creation of a reform sector is used to defuse social tensions when pressure on the land (land invasions, etc.) or revolutionary threats are excessive. It does this by allowing some vertical mobility to peasants and by creating a buffer minority of privileged peasants in the reform sector whose economic success is tied to the interests of capitalist farming and to continued patronage of the state but whose ideological allegiance is still with peasants. As such, they tend to become the political representatives of the peasantry at large and strong advocates of the social status quo that benefits them so exclusively. Land reform is here purely legitimizing of the dominant social relations. It only becomes an active political issue when this legitimacy is being questioned. It is, consequently, only in the following three

positions that land reform is an integral component of political programs.

Land Reform for National Bourgeois Revolution: The Liberal Model

For as long as feudal elements dominated agriculture, national liberal forces were directed at promoting antifeudal land reforms. With the omnipresence of capitalism, the same forces identify their targets in terms of opposing blatant external dependency relations and in terms of redefining the social and geographical location of the market for the modern sector in wage earnings as opposed to profits, rents, and exports. Both creation of a class of farmers instead of a capitalist landed elite (land reform type 8) and redistribution of land to peasants (7, 9, 13, and 14) are seen as ways of expanding the domestic market for wage goods. Since farmers and peasants are oriented more toward producing basic wage foods than the landed elite, which is principally involved in the production of agroexports, these land reforms also are proposed as mechanisms for reducing the bias against food and alleviating the food crisis. Finally, by reducing inequality, they are seen as essential to creating the economic basis needed for more democratic forms of government. In Brazil today, for example, land reform is an important rallying point for dispersed forces struggling for a return to civilian democracy.

Land Reform to Give the Land to the Peasants: The Populist Model

This position usually is argued in technocratic terms by pointing at the superior social efficiency of small farms and peasants under conditions of surplus labor: smaller farms produce more per acre than larger ones and reach a higher total factor productivity when labor and capital are valued at their social opportunity cost, which is virtually zero on small farms. Integral land reforms (types 9 and 14) to create a free peasantry are, thus, advocated since peasants' higher levels of (Chayanovian) self-exploitation lead them to deliver cheaper food on the market than capitalist farming, at least for as long as the productivity of labor is nearly equal on small and large farms (Dorner and Kanel, Lipton). As Berry and Cline put it, "land redistribution should therefore be expected to raise total output by combining underused labor from small farms and the landless work force with underused land on large farms. Nor is there likely to be a sacrifice of potential efficiency from land redistribution, because it is unlikely that there will be significant economies of scale for actual farming operations" (p. 29). Integral land reforms are, in turn, the preconditions for any meaningful effort at rural development (Wortman and Cummings). Efficiency gains are, of course, also accompanied by equity gains with the result that the populist vision of land reform offers the same logical panacea for capitalism as antifeudal reforms did.

Land Reform for Social Change: The Radical Model

A radical interpretation of the agrarian crisis in the third world essentially concludes that (*a*) Once feudalism is gone, the problems of agriculture are essentially nonagrarian as they reflect the contradictions of the global model of economic development pursued—characterized by its export and luxury orientation and by strong relations of external dependency. This, in turn, leads to a bias against food production (cheap food policies) and in favor of agroexports (comparative advantage theory). And (*b*) peasants are rapidly being dispossessed of their status as producers and transformed into a reserve of cheap semiproletarian labor.

Since resolution of the agrarian crisis consequently hinges upon broad social changes in the economy at large, land reform per se is necessary for economic development but certainly is insufficient. Yet, land reform need not wait for broader social changes to occur. The promotion of land reform itself is seen as an important instrument of social change, as a rallying cause to foment the organization of peasants and workers and the emergence of new ideas. Land reform is thus a process that is to be carried on by and not for the peasants and which is completed only with the restructure of the global social system.

Conclusion

Transformation of the agrarian structure is today more dependent upon the forces of capitalist development and, in particular, on the industrialization of commercial agriculture and the proletarianization of peasants than upon the application of land-reform policies. Solutions to food and balance of payment def-

icits are sought in medium- and large-scale capitalist farms closely integrated with international agribusiness. Peasants' demands for better living conditions are either neglected and left to the uncertainties of domestic and international migration or severely repressed. Yet, it is abundantly clear that the crises of food production and rural poverty are, if anything, worsening under the current development model. Thus, even if land reform is dead as a policy issue, it remains a key ingredient of any meaningful political program of economic development, be it of liberal, populist, or radical slant.

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The Role of the Multinational Corporation: Discussion

Terutomo Ozawa

In his thought-provoking paper, Goldberg points out that national food systems have become more and more internationalized and intertwined with each other, and that this interdependent global food system has gravitated, on the whole, toward North America, which is "the only significant surplus grain-producing area in the world." He foresees a further expansion of this globally integrated food system as a result of population pressure and an ever-rising need for food, especially on the part of developing countries, whose agricultural sector is still largely subsistent and noncommercial, with an extremely low level of productivity. Against this backdrop, Goldberg then explains how new opportunities have been and will continue to be created for key operators in a vertical food system to cross national boundaries and operate in foreign markets, that is, to become multinational.

As we all know, multinational corporations generally are regarded as a mixed bag of malevolent and benevolent forces or as institutions with psychotic behavioral patterns somewhat like those of Dr. Jekyll and Mr. Hyde. At one extreme, for example, Marxists consider multinationals nothing but a devilish instrument of capitalistic exploitation and neo-imperialism. At the other extreme, neoclassical liberals—and managers of big business in general—consider multinationals a dynamic engine of economic development and coprosperity, a savior of mankind from economic inefficiency and backwardness, and lament that its messianic mission is hampered only by the parochial interests of sovereign states. Both views have some validity, depending on the circumstances under which multinationals are allowed to operate.

The multinational corporation is by nature monopolistic in terms not only of the size of its operation but also of the superior knowledge it generates and tries to possess exclusively, and it is efficient at exploiting such knowledge; but its monopolistic power is an inevitable cause of inequity when it operates in developing countries where, in general, countervailing power either does not exist or if it does exist, is not judiciously exercised.

Goldberg describes very well the "Dr. Jekyll" side of multinationals by citing several "socially useful" cases. All these are "good citizen" citations, as they are judged, in his opinion, to be contributing to the agribusiness needs of the developing host countries. These examples of "socially useful" operations are indeed encouraging. Yet, I am still left uncomfortable about the "Mr. Hyde" side of multinationals. Goldberg does give us a warning of the power of multinationals, but he does so only implicitly by quoting a statement made by Galbraith. Goldberg says nothing about our recent experiences with the abuse of such power by multinationals. Perhaps we are too familiar with it to need to be reminded of the tragedies that occurred recently when infants in developing countries were fed baby formula marketed on a *caveat emptor* basis by multinationals.

In a section on Japanese trading companies, Goldberg advances a generalization: "In essence, commodity trading firms do not just buy cheap and sell dear, but rather recognize that they are an integral part of the food policies of the countries in which they operate and help, in cooperation with the government, to improve the efficient handling of the commodity. . . ." Here he neglects to remind us that only in the recent past Japan's trading companies have been castigated at home not only once but repeatedly for their flagrant market-cornering activities in stocks, land, wool, cotton, soybeans, timber, and other primary commodities. Neither does he mention the fact that during the Great Grain Robbery of 1972, when the Soviet Union purchased an unpredictably large quantity of wheat, Amer-

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ican grain dealers kept their operations in strict secrecy, leaving the American farmers and public in the dark—the result being that the United States played into the hands of the Soviet Union. This incident led to a new federal regulation requiring U.S. companies to report to the Department of Agriculture their sales contracts involving U.S. grain. The end result, however, was that the American grain dealers became more multinational in their activities for the purpose of evading the law, because the contracts made by their overseas affiliates were not subject to the reporting requirement.

It is equally important to remember that in the context of prevailing political conditions in many developing countries, "cooperation with the government" (a point Goldberg emphasized) does not necessarily mean that the poor masses can share the benefits from the cooperation rendered by the multinationals. Indeed, the so-called *dependencia* theory of direct foreign investment has lately shifted its emphasis from the exploitation of developing host economies by multinationals to the exploitation of the poor masses by a coalition of host government officials, landlords, elite local business interests, and multinationals. Nor does the "commercialization" of the subsistent sector advocated by Goldberg necessarily lead to an improvement in the welfare of either subsistent producers or local consumers. It is well known that the enclave type of commercial farming not infrequently drives away powerless "small farmers" from even subsistence itself.

Goldberg is no doubt quite aware of all these malevolent externalities caused by multinationals, but is intentionally concentrating on "socially useful" cases. Yet it is not certain how widespread and how significant those benevolent activities are in relation to the totality of multinationals' engagement in global agribusiness. Detractors can easily marshal an equal or even larger amount of evidence that indicates how detrimental the impact of multinational agribusiness is on the basic needs of developing economies. The best argument Goldberg can make, then, is that those "socially useful" cases do exist and that the light from at least a few candles, however faint and flickering they may be, is better than the total darkness of the current "storm over the multinationals" (Vernon).

Goldberg uses as his theoretical frame of reference only the product-cycle theory of foreign direct investment—perhaps because it is the theory advanced by his colleagues at the Harvard Business School. But his use of only this limited model, originally developed for the manufacturing sector, is clearly inadequate—and, moreover, inappropriate, particularly for the specific examples he uses in illustration. As is well known, the product cycle theory was developed to explain the specific historical experiences of American manufacturers during the 1950s and early 1960s when U.S. industry was undisputably the world's dominant innovator of products and processes. These innovations, the theory posits, have served as competitive assets for American manufacturers to exploit, first through trade and later through overseas investment.

Given the nature of the product-cycle theory, one can easily see that the examples of Japan's Zen Noh and other agricultural cooperatives and the Thai-Japanese corn agreements, for instance, cited in Goldberg's paper do not fit into the theory. He should have used, instead, the market-internalization theory of the firm, a theory originally developed by Coase and recently applied to the analysis of multinational business by Buckley and Casson. In essence, the internalization theory explains why a firm or an organization (which is a consciously coordinated entity) takes over the market (which is unconsciously coordinated by the price mechanism). We know that the main function of farmers' cooperatives, for example, is to reduce the risk of dependence on the vagaries of the market and to gain some control over prices and total supply through coordination arrangements—namely, to internalize, if not totally then partially, the market. The *raison d'être* of Zen Noh and other agricultural cooperatives is nothing but this internalization of the market.

In fact, once the concept of multinationalism is defined as a process of internalization across national borders, it fits very nicely Goldberg's own innovative notion of a commodity systems approach:

> An agribusiness commodity system encompasses the participants involved in the production, processing, and marketing of a single farm product. It includes farm suppliers, farmers, storage operators, processors, wholesalers, and retailers involved in a commodity flow from initial inputs to the final consumer. It also includes institutions which affect and coordinate the successive stages of a commodity flow such as the government, futures markets, and trade associations. These coordinating institutions and ar-

> rangements play an especially important role in agribusiness commodity systems because of the unique agronomic characteristics of the industries. The phenomenon of seasonal production of crops, combined with year-round consumption of food products, results almost inevitably in serious imbalances between supply and demand. (Goldberg, p. i)

His strong advocacy of this systems approach is nothing but a call for conscious coordination of economic activities by key operators in a vertical food system in order to control, *inter alia*, the "inevitable imbalances between supply and demand" brought about by the market. It is a call for internalization of those market segments whose transactions are not efficiently performed by the price mechanism. The activities of multinational organizations illustrated by Goldberg are good examples of this systems-focused process of market internalization.

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The Role of Export Cropping in Less Developed Countries: Discussion

Malcolm D. Bale

The paper by Hillman is a quite well-balanced representation of the issues with respect to the role of agricultural exports in development. It is a concise restatement of existing problems containing little policy advice for the future. It may be a useful survey piece to the nonspecialist, but there is little new for development or trade economists. In this respect the title is misleading. I kept waiting for the paper to focus on export cropping. Of course, it really does not. A more appropriate title would be "Export Orientation versus Self-sufficiency in the Agriculture of Developing Countries: A Survey of Issues." The paper is more notable for what it does not say than for what it says. Accordingly, most of my comments will focus on these aspects.

The main criticism of the paper is that it is a survey of what has happened and of past issues. It is long on diagnosis and short on prescription. Critical issues in agricultural development and questions that confront economists are: what is the correct valuation of agricultural output, and what advice can we provide developing countries? These are difficult questions to answer. Hillman seems to favor agricultural export-led policies. But the preconditions for this to be effective, as he states, are that growth in industrialized countries must continue at a rapid pace through the 1980s and that market access must be increased. Neither of these preconditions are projected to obtain in the 1980s. Economic growth in industrialized countries throughout the 1980s is projected to fall below the sluggish levels of the 1970s (see World Bank), and many observers in their most optimistic moments see at best a constant level of protection for agriculture during the 1980s. Thus, the question arises as to how agricultural export-oriented policies possibly could help developing countries.

One possible alternative for developing countries is to look toward increased inter-developing country trade. Preliminary work by a colleague of mine, Duncan, indicates that over the period 1963–76, the share of developing country trade to other developing countries rose. More impressive than market diversification is the changed product diversity of developing country exports. Manufactures now (1976) account for 45% of developing country exports; 22% of exports are of processed products, and only 32% of exports are primary products. This is a dramatic change from 1962, where the shares were 19%, 25%, and 56%, respectively. Within developing countries, the middle and high income countries have performed the best in terms of growth in product and market diversification. Manufactured exports from Latin America, for example, have trebled over the period, most of this increased trade going to other developing countries. The evidence from this and other work (Hughes, Stewart) seems to converge on the result that increased inter-developing country trade is occurring in a Balassa "Stages" manner, with higher income developing countries increasingly trading with lower income developing countries. Thus, it is no longer useful to classify the third world as a homogenous group as is done by Hillman. In short, there is a spectrum of development stages such that across-the-board developing-country recommendations become largely meaningless.

At several points in the paper, the issue of instability and food security arise. With respect to agriculture, the issue for developing countries is the same whether they are agricultural exporters or importers. That is, how can the inevitable problem of fluctuating export-receipts (for exporters) or foreign exchange requirements (for importers) be best

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The author acknowledges insightful discussions on this topic with Ron Duncan, Oli Havrylyshyn, Clifford Lewis, and Ernst Lutz. This notwithstanding, he makes the following formal disclaimer: The views and interpretations in this paper are those of the author and should not be attributed to the World Bank, to its affiliated organizations, or to any individual acting in their behalf.

cushioned? There have been several recent approaches to solving this problem not mentioned in the Hillman paper. There is the scheme based on insurance principles, where concerned importing countries set aside foreign exchange during times of low food prices to use in times of high food prices (Konandreas, Huddleston, Ramangkura). There is the International Monetary Funds (IMF) compensatory financing facility, where a country in balance-of-payments difficulties may draw up to 100% of its quota, if exports fall below trend. Also the European Community's "Stabex" scheme under the Lomé Conventions offers grants and interest-free loans to the associated developing countries if export earnings fall. Finally, the most recent stabilization scheme of large potential importance to developing countries is the recently agreed-upon "Common Fund" for agricultural commodities. Its establishment is a significant achievement because it is the first successful effort to bring about changes under the "New International Economic Order" through negotiations between developed and developing countries. The Fund will be the first international financial institution to be established since the Bretton Woods institutions.

The basic rationale underlying the proposal for a Common Fund was that its establishment would facilitate the formation of commodity agreements by providing finance for buffer stocks. The pooling of buffer funds across several commodities whose price swings were not in phase would be an efficient method of gaining leverage in commodity markets. That is, receipts from buffer stock sales of a commodity during its high price swing could be used to finance the purchase of stocks of another commodity whose price at that time was in a trough.

While there is a high degree of enthusiasm over the potential of the Common Fund from developing countries, whether it can achieve its goals remains to be seen. The assurance of funding for buffer stocks may not be sufficient to bring commodity negotiations to a successful conclusion. In the past, negotiations have foundered not over the issue of a buffer stock but over the question of the release-and-acquisition-prices of the buffer.

Hillman states that the agricultural sector in developing countries is taxed and subsidized. The weight of evidence of many case studies indicates that there is little subsidization but a considerable degree of taxing in agriculture in developing countries. Taxes are a serious problem severely skewing the terms of trade of agriculture in developing countries and hindering exports. While we can find a few examples of subsidies (usually on inputs), they are isolated and unimportant relative to the various taxes, levies, and price controls on agriculture. (See Peterson, Lutz and Scandizzo, Bale and Lutz, and case studies cited by the latter.)

As has been noted by Schultz and restated here, "the principal controversy surrounding food security relates primarily to man's policy role, not to the limitations of man and nature to produce enough food" (p. 16). I strongly concur with the position that various interventions in the agricultural complex have a negative effect on output. Hillman follows this by correctly pointing out that institutional changes have tended to reduce the prospect of food insecurity over the years and cites such changes as communications and transportation, enlightened attitudes, and tradable food reserves held by grain-exporting countries.

While these tendencies are correct, the world's food system is ill-equipped to handle major shocks. We are all familiar with the capacity constraint of the St. Lawrence Seaway, the bottleneck of lock 26 on the Mississippi, and the virtual closedown of the Port of Portland due to sedimentation. This infrastructure simply would not allow sudden increased shipments of stored grains in response to a foreign shortage. Further, there are infrastructure problems in importing countries. The vastness of a country such as India combined with insufficient communication and transportation make it extremely difficult for parastatals to understand, let alone manage and coordinate, the food procurement and distribution system. In addition, reports of silting-up of irrigation systems at a rate greater than the rate of development of new irrigation systems, due to an imbalance of investment in new structures over maintenance, serve to emphasize the delicate balance within which the global food distribution system operates.

I find myself in substantial agreement with the discussion on the importance of freer trade to developing countries, but I think that it is incorrect to imply that the gains to developing countries of the Tokyo Round were negligible. The value of import concessions by the European Community (EC) and eight industrial countries to developing countries has been estimated at an annual level of $12 billion in

agriculture and $28 billion in industry (GATT 1980). In addition to these pecuniary gains, developing countries stand to benefit (along with the rest of the world) from the reformation of the trading codes.

If, as Hillman states, developing countries are disappointed in the results of the Tokyo Round, it is relevant to ask why their expectations were not achieved. The reasons are important, I think, because they are frequently overlooked by economists. First, few developing countries are members of GATT and therefore few participated in the multilateral trade negotiations (MTN). Second, and more important, trade negotiations are complex and specific undertakings. Industrialized countries, when embarking on them, establish priorities as to which commodities they wish to negotiate greater market access and which commodities they are prepared to "trade-away" in return. Before going to the negotiating table, developed countries have defined their individual particular interests. Developing countries tend not to do this but rather come to the table with broad and sweeping catch-phrases, such as "greater market access," or "special differential concessions." They do not focus on narrow commodity-specific issues because, in general, they do not have the large intellectual pool of academics and support-staff backing them up with analyses of the various scenarios. When trade negotiations get down to serious bargaining at the commodity level, they normally involve only half a dozen individuals representing countries that have a particular interest in that issue. Thus, if developing countries have not examined and defined their positions along with working details of them, they tend to be left on the periphery of the negotiations. If they wish to influence the course of negotiations, it is necessary for them to have well-documented, specific cases.

I will close by supporting Hillman's view that when comparing export-oriented versus self-sufficiency policies, the weight of evidence supports strategies that encourage further exports, although, as Hillman emphasizes, there are exceptions to this. Yet, I believe that our profession must go beyond giving such broad advice, especially in view of the sluggish growth prospects in the industrialized world. Rather, we can perform a greater service to developing countries by formulating precise proposals focusing attention on alleviating specific bottlenecks in their agricultural sector.

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The Role of Land Reform in Economic Development: Policies and Politics: Discussion

Daniel W. Bromley

There are several important points made by de Janvry: one relates to his taxonomy of land reforms by country and over time, another is to be found in his four reasons land reform will not be an important issue on the economist's research agenda in the coming decade. With respect to his taxonomy, de Janvry claims that it permits the identification of the needed characteristics of future reforms, given the actual state of existing agrarian structures. He then argues that this gives us a basis from which to seek answers to the question about why land reform appears to be a dead policy issue in most countries. I have four concerns with respect to his treatment of the land reform issue and will now turn to a brief discussion of each.

My first concern is that the four reasons he offers for why land reform is a dead policy issue do not follow uniquely from his analysis but could be derived quite independently. De Janvry offers the following reasons: (*a*) the political alliance for land reform must be capable of opposing an established capitalist class in agriculture; (*b*) all efficiency gains from land reform have virtually been exhausted; (*c*) domestic demand is no longer important as a macro consideration since the industrial sectors are primarily export oriented; and (*d*) the ruling class will only give in grudgingly and in small doses. I see little unique about his paradigm or his taxonomy which produce these findings. To put it differently, it is possible to arrive at these conclusions quite outside of his analysis.

My second concern is that the above list of reasons for the demise of land reform as a policy issue, while rather reasonable in spite of my contention that they do not follow from his analysis, misses one very important consideration. A plethora of changes have occured in the developing economies which, in combination, drive down the economic role of land to the point that in some instances access to—or control over—land may be quite irrelevant. Perhaps this is implicit in his second item on the above list, but its importance warrants special mention.

The advent of high-yielding varieties, increased reliance on chemical pesticides and fertilizers, control over irrigation water, and the multitude of ways in which urban dominated agricultural policy can countermand any nominal gains from better land use opportunities all combine to render—in many instances—land ownership quite irrelevant. There are so many factors which impinge upon the economic environment of a newly landed peasant that the legal and/or economic relations of that person to the land resource may be quite beside the point. Land cannot be considered important in either a policy or a political context when it is often so irrelevant in the ultimate reckoning of a peasant's economic position.

My third concern is that his paradigm, which concentrates on modes of production and class relations, is overly rigid and not terribly helpful analytically. For instance, he says that a reform is an institutional innovation promoted [permitted?] by the ruling order to overcome economic and/or political contradictions without changing the dominant social relations. However, if the agricultural population is transformed from one of 10% landowners and 90% wage laborers/tenants to one of 75% landowners and 25% wage laborers/tenants, it is hard for me to see how the dominant social relations have not been seriously altered. The fact that the nonagricultural sector remains capitalist, along with the agricultural sector, may make it seem that social relations have not changed much, but this is

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an artifact of a model that sees social relations as derivative of modes of production writ large. It is the old capitalist/socialist dichotomy, and here it seems to miss very important changes in social relations even in the absence of a transition from capitalist to socialist modes.

To de Janvry, revolution is the only thing which will alter social relations, and here he would mean a transition from feudal to capitalist, or feudal to socialist, or capitalist to socialist. This sort of rigid dichotomy does not seem very helpful analytically, especially when it leads us to conclude that dominant social relations have not been altered by a massive redistribution of land within the capitalist mode. When this new economic opportunity is created for the formerly landless, few could deny that sweeping changes have occurred in the social relations governing rural life.

My fourth and final point concerns de Janvry's use of the term "land tenure." He says that land reform changes the modes of production, the associated class structure, and the pattern of land tenure. I may be missing something here, but I consider it more helpful to say that land reform alters four aspects of the man/land interface: namely, (*a*) who controls land; (*b*) who may use land; (*c*) who reaps the benefits of land use; and (*d*) who bears the costs of land use. Once said, we then can explore the nature and extent of changes in these four factors, and we might conclude that the dominant mode of production has been changed, and that this will then hold important implications for social relations. Simply put, I question his causal chain which runs from modes of production to class structure to land tenure.

In closing, let me emphasize that in spite of my concerns, I found the paper to be useful, informative, and an important new perspective on a topic which—as he indicated—will remain an important political issue. The symbolic value of land will remain prominent, even as its economic value may be allowed to decline.

Books Reviewed

Boris, Constance M., and John V. Krutilla. *Water Rights and Energy Development in the Yellowstone River Basin: An Integrated Analysis.* Baltimore, Md.: Johns Hopkins University Press for Resources for the Future, 1980, xiv + 278 pp., $25.00.

The staff at Resources for the Future has again accomplished the difficult task of producing a book that has substantial relevance for both policy makers and academicians. Boris and Krutilla's analysis of water use alternatives in the Yellowstone basin, with emphasis on the issue of water availability for energy development, constitutes a useful treatment of an important policy issue.

The approach used by the authors consists essentially of four parts: (*a*) a detailed specification of legal and institutional constraints to water development and use; (*b*) an assessment of competing water use demands, including demands for coal mining, processing and transportation, electrical generation, irrigation, municipal use, industrial use and instream flow reservations; (*c*) a discussion of the interrelationships between water quality and water quantity; and (*d*) development of a refined hydrologic simulator used to specify water availability under a variety of water use scenarios. Their analysis is limited to surface water considerations and does not consider the economics of alternative uses.

One particularly noteworthy point which runs throughout the book is that the authors remain realistic and never fall prey to the god of efficiency or to the narcotic of idealism. Most analyses of water use alternatives with which this reviewer is familiar use some form of economic efficiency calculus to predict what will and/or should happen under selected scenarios, with an often times consequent loss in realism and policy usefulness. In contrast, the authors recognize the relevance of economic considerations, but are willing to acknowledge and accept the predominant role of political criteria in water allocation. They then proceed to follow this acknowledgement with a very detailed and complete assessment of the legal-institutional environment in the Yellowstone basin. Indeed, their treatment of existing water rights, including the federal-reserved water rights issue, constitutes an excellent example of how to integrate effectively institutional and engineering considerations in policy analyses.

The single major deficiency in the analysis is the author's failure to consider adequately the potential significance of ground water as an alternative source of supply. The authors note that substantial ground water supplies are physically available from the Madison formation, but do not explore extensively to what extent ground water could constitute an economically feasible source of water for some uses. The absence of information about this issue, although admittedly outside the scope of their study, makes it hazardous to draw definitive conclusions about the potential limits or trade-offs associated with energy developments in the Yellowstone basin.

In general, the book is extremely readable and should be easily understood by water or energy specialists and generalists alike. In view of the significance of the Yellowstone basin to the national potential for coal development, the book should be must reading for the full range of people engaged in water and energy policy formulation both within and outside the region. The book also can serve as a useful reference source for background information about a wide range of related issues, including everything from Indian water rights to the amount of water required for a coal slurry pipeline. Last but not least, scholars engaged in similar work will find the book an excellent example of how to approach complex policy issues in a manner that is simultaneously useful and methodologically defensible.

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Campbell, Keith O., *Food for the Future,* Lincoln and London: University of Nebraska Press, 1979, x + 178 pp., $12.50.

Following a brief discussion of the trends in food demand and the current state of world agriculture, the author addresses the issues associated with expansions of world food supplies. The role of agricultural research and technological change receives a great deal of attention. Other factors important for the future food supply, e.g., resource constraints, energy supply, rural institutions and infrastructure, and government policy are also treated in considerable detail.

Considering the period up to year 2000, the author firmly believes that world food supplies can be expanded to meet increasing demands. While he rejects predictions that we are headed towards catastrophic food shortages on a global level, he concludes that governments must place very high priority on efforts to expand food production. Research and technological change is considered by the author to be the key to rapid growth in food supplies. The need for expanded public investment in agricultural research is emphasized. It is felt that current underinvestment in such research may continue into the future because of the weak lobbying position of the agricultural sector. The need for

public policy to facilitate technological change and expansions in food production is also emphasized, and it is argued that appropriate economic policies are much more important than expanded advisory services to farmers. A set of such policy areas is presented and a number of existing policy measures biased against agriculture and food production are discussed. The author does not feel that resource constraints are likely to impose serious limitations on efforts to expand food production during the next twenty years and he argues effectively and convincingly against the use of energy input/output ratios instead of economic relationships as a guide for resource allocation in agriculture.

The book is focused on the supply side of the food problem and does not promise to treat the demand side. However, such a focus does not justify the implicit view that rapid expansions of the food supply should be considered as a goal of a higher order and not a means to improve the well-being of people. The author seems to argue for rapid expansions in food supplies for its own sake and sees little or no reason to consider side effects when planning the strategy for obtaining such expansions.

Poverty-oriented development strategies, redistribution of productive assets, e.g., land reforms, and programs to alleviate malnutrition and starvation caused by lack of purchasing power are dismissed if they in any way conflict with the goal of expanding food supplies. The author seems to think that such conflicts between growth and equity are the rule rather than the exception. Efforts such as subsidies and price support, which encourage low income farmers to stay on the farm and, thus, slow down rural to urban migration, are hindering "progress" and should be avoided according to the author. Even the "family farm" falls by the wayside if a different tenure system is more efficient in expanding food supplies.

Although the author provides no viable alternative for the rural poor, he suggests that we recognize the "antiprogressive" nature of poverty-oriented rural development programs such as those promoted in developing countries by the World Bank and the U.S. government.

To summarize, Campbell provides us with an excellent analysis of the principal factors influencing the future food supply. The message is clear: expanded public investment in agricultural research and technological change combined with investment in rural infrastructure and public policy to facilitate rapid food supply expansions are essential to meet future food demands. With such investments and policy, resource constraints, including energy scarcity, are not likely to be of major concern in assuring the required supply expansions.

While Campbell recognizes the existence of severe poverty, malnutrition, and starvation in many developing countries, he suggests that these problems be dealt with separately "as part of a more general attack on the problem of poverty" (p. 146). Yet he dismisses poverty-oriented rural development programs as inappropriate and undesired by many developing countries. However, in a world where a large proportion of the absolute poor depends on agriculture for their livelihood and where food expenditures by the poor account for a large share of total incomes, an agricultural development strategy that ignores distributional effects is grossly inappropriate. Growth and equity goals must be integrated into the strategy—not dealt with separately. Poverty problems in high income countries such as Australia and most of Western Europe may be dealt with through separate welfare programs. But a viable solution to the poverty in most developing countries can only be found within an integrated growth/equity development strategy.

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Goldberg, Ray A., and Richard C. McGinity. *Agribusiness Management for Developing Countries: Southeast Asian Corn System and American and Japanese Trends Affecting It.* Cambridge, Mass.: Ballinger Publishing Co., 1979, xxv + 643 pp., $17.50.

The authors have undertaken the monumental task of comparing and contrasting the organization of production, marketing, and consumption of corn in the United States, Japan, Indonesia, Thailand, and the Philippines. From these diverse economic systems the authors attempt to draw generalizations as a guide for private and public decision makers for "developing an effective food system." Failure to accomplish this goal is more a reflection of the complexity of the task than on the capabilities of the authors.

The focus of the book is agribusiness, defined to encompass a complete vertical cross-section of the corn industry from geneticists to consumers in each country. The firms and agencies comprising these systems are described in detail, and differences in scale and structure are amply illustrated with 269 tables and 50 figures. With only 149 pages of text, the book relies heavily on the twenty-one case studies (358 pages) to provide insight into the decision-making processes of producers, processers, cooperatives, and government agencies in each country.

Although the tables and diagrams provide a valuable resource, the authors fail to utilize their full potential. For example, figure 5–11 and 6–1 are identical, an entire page is allocated to each, but they are scarcely mentioned in the text. These complex flow diagrams would benefit from additional explanation and interpretation.

The description of the market structure in each country facilitates comparisons among the contrasting economic systems. However, the lack of an

analytic model within which the selected structural variables are related to performance creates difficulty for the reader in sorting out desirable policy actions. Industry concentration ratios within the corn-marketing sectors are often related to decreased competition and abuse of market power. Yet no guidelines are offered as to appropriate firm numbers. In the Philippines, 24,000 wholesalers are not sufficient to ensure competition in purchases from farmers; while the Thailand corn industry is described as very competitive, with five firms owning all port facilities. It appears that the word "competition" is sometimes used as a behavioral term and sometimes as a structural variable. Differing degrees of competitive structure are not identified as the description moves vertically through each segment of the system. Identification of the structure and performance variables and relationships would add some analytical depth and perhaps facilitate drawing generalizations from the detail contained in the case studies.

The human interest details add a sparkle to the lengthy case studies, but the central theme is sometimes obscured as you worry with Mr. Pullin about the lease that expires in August and whether or not he should purchase those extra feeder pigs. The information about the family from the Philippines living in a nipa-roofed hut with a secondhand sewing machine also provides an interesting background for understanding the small farmer's role in the Philippine corn system, but the relevant information could have been condensed significantly.

A few errors occasionally creep into the descriptive material. For example, "milling intransit rates in the U.S. ceased to exist by the early 1970's" (they are still in use by many grain and soybean processors); "the typical covered grain hopper car carries 60 tons of corn" (70% of the current covered hopper fleet is in 100-ton hoppers); "a bushel of corn weighs about 56 pounds" (it weighs exactly 56 pounds, by definition). Despite several of these minor errors, and a number of typographical errors that could have benefited from closer editing, the book amply demonstrates the role of economic incentives in stimulating production response and the importance of the vertical system and coordinating mechanisms to development of an economically viable commercial corn sector.

The authors' description of the purchases of U.S. country elevators by international grain firms raises many interesting questions about causes and effects. Unfortunately, most of these questions are left unanswered as the section digresses into the issue of foreign ownership of farmland—of questionable relevance since there is no evidence that farm ownership is related to the vertical integration of the grain firms.

In the concluding chapter the authors face up to the limitations of the case study approach in meeting their objectives. In summarizing all of the experiences, they conclude that no pattern for success or failure has developed; a program that worked in one region failed completely in another. The book succeeds in illustrating two important principles that I would have liked to see given more emphasis. The first is that policy changes related to commodities must take into account the entire vertical system and its interfaces. The second principle is that when the economic incentives are present, individual decision makers will develop the production and infrastructure necessary so long as government policies do not interfere. Although the authors were unsuccessful in constructing a blueprint for developing an economically viable corn industry, their identification of the essential vertical relationships within and between countries provides useful insights for policy makers in developing economies. Students of grain marketing and economic development alike will benefit from these insights and will enjoy the detailed description providing a better understanding of the corn systems around the world.

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Helmers, F.L.C.H. *Project Planning and Income Distribution*. Boston: Martinus Nijhoff Publishing Co., 1979, 295 pp., price unknown.

The focus of this book is on project analysis and selection in developing countries. It consists of two parts—one devoted to conventional project-planning criteria and the other to income distribution aspects. The first part is a thorough critical survey of the state of the arts with reference to such issues as the valuation of project benefits and costs, the analytics (e.g., optimal scale and timing) of project planning and project ranking. The second part is the real "raison d'être" of the volume. It covers such difficult questions as social welfare and benefit-cost analysis and intertemporal and interpersonal income distribution aspects. Recognition and adoption of poverty alleviation as a major policy objective leads to the major theme of the book, i.e., that income distribution objectives have to be incorporated into project analysis.

The opportunity cost doctrine is accepted in part 1 as a starting point for the measurement of costs of production. A whole chapter (3) is devoted to presenting various methods which have been proposed to estimate the shadow prices of different inputs. The discussion of how linkage effects among projects, externalities and macroeconomic imbalances (unemployment, balance of payment problems) should be incorporated in project analysis suffers from having excluded the programming approach to these questions. It certainly cannot be taken for granted—as the author does—that programming models cannot depict the real world situation and

that the shadow prices which they generate are "extremely crude" (p. 11). Many agricultural economists will be shocked at the rejection of the programming approach in helping to determine shadow prices in a variety of agricultural project settings. It could be argued that shadow prices generated by programming models are often as realistic and operationally useful as those generated by alternative partial equilibrium methods and, in any case, can provide a useful check on the latter.

The heart of the volume is contained in part 2, which is devoted to income distribution aspects. On the whole, the discussion is thorough, clear, and objectively presented. Helmers makes a strong and convincing case for the incorporation of the distributional effects of projects reflecting societal values. He starts by rightly rejecting the so-called compensation tests. If in reality compensation does not take place, it is totally irrelevant to use a test according to which the poor could, in principle, have been compensated. After undertaking an interesting critical review of the theoretical and empirical literature on the marginal utility of income schedule, the author concludes that even if it were possible to obtain accurate estimates of this schedule at different income levels, it still would not be appropriate to use these as weights to make interpersonal comparisons. The correct weights should be derived from societal values. This leads the author to postulate such weights for a typical developing country on the defensible assumption that society only cares about the very poor and the very rich and is relatively indifferent regarding the income distribution which prevails in between.

Even though projects should be subjected to the above type of social rate-of-return analysis, the author introduces what amounts to a lexicographic decision rule regarding project selection. First, only those projects whose economic rates of return are higher than the opportunity cost of capital should be accepted. It is only if this efficiency criterion is met that the second (equity) criterion—the social rate of return analysis—comes into operation. This guarantees that all projects have, at least, an acceptable economic rate of return. The above decision rule is, of course, normative and reflects a particular type of social welfare function which ignores equity considerations altogether, as long as a minimal efficiency threshold is not met. The selection rules adopted by the author might be interpreted as a compromise between the old traditional (efficiency-oriented) approach to project analysis and the evolving more equity-oriented approach.

The incorporation of distributional objectives in project analysis requires the latter to move away from a strictly microeconomic framework towards the no-man's land between micro- and macroeconomics. Perhaps, fearing to be soiled by such a move, Helmers adopts a negative position regarding a macroeconomic approach to development planning. To quote him: ' A poverty-focused strategy is necessarily a micro-economic strategy and must rely on project analysis to help determine which projects and which programs will indeed raise the incomes of the poor and which must be rejected" (p. 262). It would be more accurate to say that a combination of a conducive macroeconomic policy framework and microeconomic project analysis is required. In fact, Helmers seems to recognize this in his short section on national planning and project planning (pp. 13–15). The position of the author may be somewhat inconsistent on this issue.

In conclusion, this is a very good treatment of the theoretical underpinning of project analysis. This volume deserves to take its place among a small set of reference books in this area. It deserves to be read by practitioners and students of project analysis alike.

Erik Thorbecke
Erasmus University and *Cornell University*

Hopkins, Raymond F., and Donald J. Puchala. ***Global Food Interdependence: Challenge to American Foreign Policy.*** **New York: Columbia University Press, 1980, xvi + 214 pp., $20.00.**

In the late 1970s, with the return of favorable weather and the consequent large harvests around the globe, the priority of food aid and food security issues on the agricultural policy agenda declined. This book is intended to refocus attention on these issues. The authors examine the U.S. policy response to world food issues in the 1970s and propose policies which would improve the ability of the United States to respond to future food needs.

Hopkins and Puchala's central thesis is that the global food system has not been performing satisfactorily and they recommend several policies to improve its performance. First, public policies are proposed to regulate vagaries of agricultural supply, rectify policy distortions, and restrict abuses of the marketplace. These policies include internationally managed grain reserves, bilateral trade agreements, and international commodity agreements. Second, they conclude that food aid is beneficial to recipient countries, and it is in the interest of the United States to continue food aid programs, probably indefinitely. Because of this, the United States should clarify food aid priorities and emphasize the developmental aspects of food aid. Third, the authors argue in favor of improved coordination between U.S. government agencies responsible for food aid. Specific recommendations include an increased role for middle level specialists on interagency committees, greater appreciation of food aid issues at senior levels, and better integration of the private sector into research and policy

deliberations. Fourth, they recommend a more active role for the United States in international food organizations. Finally, the authors argue for a more systematic consideration of long-range future scenarios in policy recommendations rather than relying only on short-term analysis.

The authors are explicit in stating the arguments underlying their policy recommendations. They are political scientists and take a broad view of the global food system, incorporating the economic, political, and social institutions that shape food policies. For example, they emphasize the political, legal, and institutional aspects of land in addition to economic factors. This broad perspective is one of the major contributions the book offers to agricultural economists. However, this general perspective may be troublesome for some economists. Although most of their economic arguments appear reasonable, many are based on concensus opinions of economists with little supporting empirical economic analysis.

Hopkins and Puchala's analysis leads to conclusions which will challenge some economists' views of global food issues. They criticize economic theorists for being more concerned with substituting abstract economic logic for empirical analysis and concrete policy recommendations. They write (p. 71), "A world of exploding populations, predictable food deficits, erratically fluctuating prices, and growing dependence upon an imperfect market is hardly served by philosophic debate [on grain reserves] in lieu of action." They also conclude for institutional and political reasons that food aid is a more realistic policy than income transfers. Some economists argue in favor of a cash transfer on the basis of economic efficiency. The authors contend that if serious efforts were made to substitute income transfers for food aid, diverse political interest groups would mobilize against the policy. Further, even if such counter-efforts failed, there is little reason based on the politics of foreign aid to expect that suspended food aid flows would be compensated by increased cash flows. Hopkins and Puchala's conclusions offer economists an opportunity to reexamine their policy recommendations on food issues.

The major contribution of the book is the balanced discussion of global food issues. They are concerned about the future, and while approaching global food issues with a sense of urgency, are optimistic. The policy recommendations reflect a belief that the existing system can be responsive to food needs, albeit with modifications. They do not condemn the current world food-trading system, but propose positive changes of limited scope, such as international grain reserves, and improved inter- and intra-government coordination. As might be expected, their policy recommendations probably will not satisfy the "hunger lobby," nor will they be acceptable to those who view the issue of global food security with skepticism. But the balanced concern of the authors is effective in refocusing attention on global food issues, and their policy recommendations are worthy of serious consideration by agricultural economists.

Philip L. Paarlberg
USDA ESS

Jackson, David H. ***The Microeconomics of the Timber Industry.*** **Boulder, Colo.: Westview Press, 1980, xiii + 136 pp., $18.50.**

The purpose of this book is "to provide a better linkage between microeconomic theory and forestry" (p. xii). To achieve his purpose, the author states two objectives: (*a*) theoretical development of the firm's timber supply function with time dependent production, and (*b*) aggregation of individual firm supply functions into a market supply function. These models are subsequently used to analyze the effect of various types of taxes on timber production and market supply. The central focus of the book is on the actions of private timber producers with little theoretical development of public timber supply or demand.

To develop the firm's supply function with time-dependent production, a wealth maximization model is constructed with output a function of establishment (reforestation) inputs and time. Time-dependent production necessitates the discounting of this wealth equation. Timber production is assumed the land's highest and best use; thus, the discounting procedure for an infinite series of timber rotations (production cycles) is used. Utilizing this equation, comparative statics are used to expand and modify Gaffney's 1957 financial maturity study. The major contribution of this analysis is that both time and input levels are allowed to vary rather than just harvest age as in Gaffney's study. This modification results in a lengthened rotation age instead of a shortened one, as predicted by Gaffney, given an increase in the interest rate.

In deriving the firm's supply function, optimal production decisions at two different output prices are compared. It is shown, assuming a fixed land base, that timber supply is a positive function of output price. The response to an increase in interest is negative. Additional production models of increasing complexity, including heterogenous product quality and n-decision alternatives, are presented, but are not used to derive more complex supply functions.

The industry's supply function is derived from the simple production function of one input and time. Since the firm's supply function is in terms of output per acre per unit of time, it must be multiplied by the acres in each firm and then added across all firms to derive the timber supply function for private industry. In this model, the land base is not fixed and changes in timberland acreage are viewed as the entry or exit of firms from the market.

Therefore, an elastic timberland market would result in a more elastic timber supply

To develop the timber market, public timber supply is assumed inelastic at a governmentally controlled output per year. A simple timber demand function is specified and market equilibriums under different conditions are analyzed.

In the fourth chapter (of five), there is an abrupt change in the subject matter from theoretical development to policy analysis. The previously developed models are utilized to determine tax impact and incidence on intrafirm resource allocation and market supply and price. Sales or excise taxes, capital gains taxes, and accrued income taxes are nonneutral and cause shifts in timber supply. Three kinds of land taxes and ordinary income taxes are shown to be neutral.

A shortcoming of the book is the lack of an in-depth discussion of the dynamics of the entry or exit of land from timber production. This deficiency arises from the assumption that timber production is the highest and best use of the land. Since the number of acres devoted to timber production could significantly influence supply responses, some type of land market is needed to determine the net impact of price and interest changes on supply. Another area of weakness is the derivation of the firm's supply function. The function is derived from a comparison of two static points rather than from the profit or cost function. While this is probably due to the inclusion of time dependent production, the author fails to explain this deviation from the more classic microeconomic development of the supply function. Numerous typographical errors make certain statements and equations difficult to understand.

The book's contribution is its demonstration of microeconomic theory in a forestry context. As such, it may be useful as a supplement to graduate courses in forest economics. Economists studying timber production or forest taxation also may find the book interesting.

W. L. Mills, Jr.
Auburn University

Reference

Gaffney, Mason M. *Concepts of the Financial Maturity of Timber and Other Assets.* Agr. Econ. Info. Series No. 62, North Carolina State University, 1957.

Peterson, Trudy Huskamp. *Agricultural Exports, Farm Income and the Eisenhower Administration.* Lincoln and London: University of Nebraska Press, 1980, xii + 222 pp., $15.95.

When Dwight Eisenhower won the presidential election of 1952, the Republicans came steaming into office determined to uproot New Deal "socialistic" programs. One sector that they felt was ready for deep plowing was the farm income support apparatus. This included acreage allotments, price supports, and commodity diversions at home and abroad.

The direct payments of wartime had been discontinued, and Agriculture Secretary Charles F. Brennan's plan for such payments on perishable commodities was not enacted. Acreage limitations remained as the main instrument for reducing surpluses and holding up prices. Republican agricultural leaders proposed to get rid of this and handle the surplus problem by boosting export sales of grains, cotton, and other major products.

This book, by a historian with the National Archives and Records Service, describes the background and political maneuvering which brought forth the Food for Peace legislation of 1954 (Public Law 480) and the operation of the law in the Eisenhower years.

Food for Peace, that is, aid for poor countries, was a significant objective behind the new law, but commercial export development was even more important in the minds of the Farm Bureau leaders, who strongly advocated the program, and Ezra Taft Benson, the new Secretary of Agriculture. Sales of farm products abroad at submarket prices were to pave the way for expanded commercial trade. Donations also would promote American foodstuffs. This would overcome the surplus plague and avoid the ideologically repellent crop controls. (Government intervention in foreign trade apparently was less dreadful to the G.O.P. ideologues.)

Export subsidies were not new, of course; they had been used in various ways—Export-Import Bank loans, Marshall Plan grants and loans, Section 32 funds from customs' revenues used for export subsidies, and Commodity Credit Corporation relief sales and donations, as well as barter trades with agricultural commodities. P.L. 480 was a plan to enlarge and systematize the whole business.

Secretary of State Dulles saw the program as a tool for pursuing political aims in strategic areas. The new law authorized sales to "friendly" countries—not to the USSR or a country "dominated or controlled by the foreign government or foreign organization controlling the world Communist movement." How times have changed! In 1972, Soviet grain purchases were welcomed with subsidies. A partial grain embargo on sales to the Soviet Union in 1980 was regarded as intolerable by the same pressure groups which applauded the P.L. 480 embargo.

P.L. 480, like the export disposal programs which preceded it, proved to be an inadequate substitute for crop acreage limitation as a means of supporting farm income. Surpluses still accumulated in the 1950s, and in the 1960s crop acreage controls returned.

Peterson's book is an elaborately documented

study, as would be expected from an archivist. The author relied heavily on papers of USDA luminaries, including those of Don Paarlberg, a Fellow of this Association who was an economic adviser to Benson and later Food for Peace administrator. Paarlberg was one who cautioned against excessive dumping of commodities, fearing that this would undermine commercial markets, including those of U.S. allies—which it did to some extent. But these warnings were overridden by the impulse to shuck the government control system at home.

One inheritance of the program is the dependence of many less developed countries on the U.S. granary for their reserves, which has inhibited rather than helped agricultural development in those countries. Another was the misuse of Food for Peace to pursue military and political objectives instead of economic aid. These outcomes were foreshadowed in some degree during the debates prior to enactment of P.L. 480—but ignored.

The Peterson book is valuable for reference, despite a lack of sophistication in interpretation of the underlying economic issues. It is excellent as a reporting job on the politics of agricultural trade during the 1950s.

Lauren Soth
West Des Moines, Iowa

Schmitt, Bernard A. *Protein, Calories and Development.* Boulder, Colo.: Westview Press, 1979, xxi + 224 pp., price unknown.

In the foreword to this book, Ray Canterbury describes its scope as staggering. Indeed, the book more fruitfully could have become three journal papers. The first part of the book, covering the first three chapters, is a useful overview of recommended daily allowances for proteins and calories and the importance of diet quality as an indicator of food adequacy. The second part, chapters four and five, is about projections of domestic food production for developing countries using cross-sectional data. The balance of the book, chapters six and seven, is a yet-to-be-finished paper on food policies. Forecasts are developed for a number of food commodities that represent the principal sources of energy and protein in human diets (wheat, rice, coarse grains, pulses, sugar, starches, and livestock products). The work is innovative because the productive capacity of agricultural labor is augmented through three measures of food availability (a nutritional index, per capita calories, and per capita proteins). The approach is described as the "cyclonutritional" phenomenon whereby nutrition (food intake) is said to affect human capital, which in turn affects agricultural output through enhanced labor productivity.

Data for 1970 from developing countries that are significant producers of each commodity are used in the estimation of unrestricted Cobb-Douglas production functions. Labor, land, and fertilizer are used as conventional factors of production to explain physical output of each commodity. Technology differences among countries are said to be held constant in the regression analyses by including a technological index. The technological index is a complex composite of several ordinal and nominal scales of concepts such as mass communication, political commitment to economic development, character of the agricultural organization, and modernization of techniques in agriculture as well as indices developed by other authors. The rationale and scalar properties of the technological index is not complete and lacks specificity on what the index measures.

The data-processing effort is impressive. About seven of the twenty (or so) regressions which were run for each commodity are presented. No logic is given for the particular choice of variables in the regression results that are presented. Furthermore, there is no consistency of presentation, so that the effect of a given variable in one commodity may not appear in the same specification for another. Thus, there is no clarity regarding the hypotheses being tested.

The estimates of the effect of conventional factors seem robust across equations within commodities. Estimates are presented as output elasticities without reference to what is being held constant. The estimated effects of land are presented as substantially larger than the estimates of other authors, yet no meaningful effort to explain the differences is presented. The results are said to point out the importance of land in developing agriculture as opposed to the capital intensive agriculture of developed countries. Furthermore, the claim is made that the technology index eliminates any confounding of the land effect. The technology index was not significant for wheat production, and this was explained away by appeal to a colinearity with fertilizer. Yet data for Argentina, Mexico, and India are excluded from the wheat regressions, as are irrigation and high yielding varieties.

The stated novelty in the analysis is the inclusion of nutritional variables. Two equations are presented which show proteins as significant, another two show the quality-adjusted nutritional index as significant, and yet another two equations show each of these to have a significant interaction with labor. In these latter two, no main effects are tested, so it is not clear that the interaction effect is significant, per se. Much of the main policy recommendation hinges on this result.

Selected output elasticities are then combined with projections of factor use to 1985 to project country-by-country output for each commodity. The projections and forecasts all assume constant relative prices and no reallocation of factors among commodities. When compared against United Nations Food and Agricultural Organization demand projections, all commodities, except sugar and

pulses, show deficit balances. These imply a shortfall of 120 to 174 calories per capita per day in the developing world. This is a cereal equivalent of 60 million metric tons per annum.

In the conclusions, trade and aid are said to be insufficient to fill the gap. The "Green Revolution" is said to be included already in the data (recall the exclusion of Mexico and India from the wheat analysis) and to contribute little because the new high-yielding varieties are fertilizer-intensive. Land and fertilizer use would have to be increased by half again the projected growth to fill the forecasted nutrient gaps. A redistribution of nutrients to agricultural labor could yield multipliers of 1.1 to 1.2 on food output. Nothing is said about how this targeted food transfer is to be achieved. The conclusions and policy recommendations form an interesting set of hypotheses on which to begin work on the third paper.

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Research Triangle Institute

Stevens, Christopher. *Food Aid and the Developing World*. New York: St. Martin's Press for the Overseas Development Institute, 1979, 224 pp., $22.40.

This book does not do precisely what its title implies. It focuses on four African recipients (Botswana, Lesotho, Tunisia, and Upper Volta), and the first six chapters present a miscellany of facts and figures about the food aid practices of each of the donors active in those four countries and the experience of each of the four countries in administering various types of food aid projects and programs.

Yet, the focus on Africa is an important contribution of the book, and it leads in an indirect way to the more general insights the author clearly wishes to convey. Much of the earlier empirical literature considers the experience of the larger food aid recipients in Asia and Latin America. Focusing on Africa provides a perspective on smaller recipients and on the targeted project approach which has been missing from previous work. To the author's regret, empirical data for doing rigorous impact analysis are simply not to be had in these or other small African countries. This lack does not prevent him from giving good evidence for each of the points he wishes to make. The chapters on the recipients and on the uses of food aid (3, 4, 5, and 6) could have been improved by a greater effort to provide comparable secondary data for all of the countries and to give a clearer statistical picture of the relation of food aid flows to domestic production and total imports in quantitative terms. However, the net result of Stevens' more spotty use of numbers is still to give a fairly clear picture of how food aid operates within the economic and political framework of each of the four countries under study.

A second valuable contribution is Stevens' taxonomy of the uses of food aid. By distinguishing three generic types of food aid and classifying various types of targeted projects and bulk supply programs accordingly, he sharpens our understanding of the relation between different food aid objectives and the approach selected for implementation. His three categories are food for cash, food for nutrition, and food for work. The primary aim of food for cash, in his view, is "to realize the money value of the food aid," which can be achieved either through open market sales or through institutional feeding programs, as in secondary schools and hospitals. The primary aim of food for nutrition is to improve the nutritional status of people who are particularly vulnerable or deserving, which is usually attempted through mother/child feeding programs or through primary school lunches. The primary aim of food for work is to subsidize productive employment for the very poor by providing a ration of food in lieu of cash wages, which can be accomplished either through public works projects or through resettlement and farmer incentive schemes.

In chapters 7, 8, and 9 Stevens presents his conclusions and findings with respect to the impact of food aid on nutrition, consumer prices, and agricultural production. In these chapters he reviews the evidence from individual projects and programs in each of the four study countries. Because his four countries are each quite different and the coverage of different types of food aid activities is broad, these chapters are sprinkled throughout with interesting microlevel observations. Stevens gives plenty of specific instances in which food aid has had a negative impact. Nevertheless, his examples of positive, though sometimes unintended, results are sufficiently numerous to justify his more general point that there is nothing inherent about food aid to support some critics' claims that its effects will always be bad.

Christopher Stevens stands firmly with those who believe food aid can be a useful development assistance tool. In his concluding chapter (10), he gives some cogent reasons for this view. For one thing, he points out that "for political reasons it is difficult to focus openly on two of the most attractive features of food aid: first, that it often represents free foreign exchange, and second that it is a subtle means of providing income-in-kind to poorer people" (p. 204). Support for food aid comes from exporters, who want the food to be additional to commercial imports, and hunger lobbies, who want the food to feed the starving millions. Since the real accomplishments of food aid are not the ones its strongest supporters advocate, it is clear why food aid is in trouble in some quarters, despite its potential importance for development in many third world countries.

For another thing, in the effort to link food aid more effectively to rural development activities,

both supporters and critics judge the effectiveness of the linkage according to whether or not the activities supported are the most promising for rural development. To Stevens, this is a fundamentally misguided approach. Food aid, he says, "should be used in activities that can use it effectively and are not destabilized by it" (p. 207). Those who claim that some methods of disbursing food aid are inherently superior to others simply because they link directly to fashionable projects or policies would actually constrain food aid from being used in the variety of ways necessary to achieve its maximum potential effectiveness.

For those who read it and absorb its message, Stevens' book should help clarify what food aid can and cannot do and give practical guidance to those actively attempting to improve its developmental effectiveness.

Barbara Huddleston
International Food Policy Research Institute

Ph.D. Recipients by Subject

Editor's Note

We return to publishing the annual Ph.D. listings in the *Journal*. In 1979 and 1980, they appeared in the March and May issues of the *AAEA Newsletter*. Readers wishing copies of the 1979 and 1980 *Newsletter* listings may write to the editor.

Agricultural Data

T. L. Browning, B.S. University of Maryland, 1967; M.S. Pennsylvania State University, 1969; Ph.D. University of Minnesota, "Measuring Cattle Breeding Herd Growth and Disappearance Flows and Incorporating Them into USDA Farm Income and Productivity Measures."
Ralph D. Christy, B.S. Southern University, 1975; M.S. 1977, Ph.D. Michigan State University, "An Information System Case Study: The Michigan Processed Potato Industry."

Agricultural Economics, General

Galal Mohamed Abdo, B.S. 1958, M.S. 1966, Cairo University, Egypt; Ph.D. Mississippi State University, "Analysis of Farm Adjustment Potentials in the Northern Brown Loam Area of Mississippi."
J. J. Ahern, B.S. California Polytechnic State University; M.S., Ph.D. University of Maryland, "Analysis of the Implications of the Demand for Racing on State and Industry Revenues in Maryland."
Charles Benbrook, B.A. Harvard University, 1971; M.A. 1980, Ph.D. University of Wisconsin, "Farm Structural Characteristics Management Practices, and the Environment: An Exploratory Analysis."
D. Colacicco, B.A., M.S., Ph.D. University of Maryland, "A Determination of the Optimal Set of Compost Characteristics."
Randall Arnold Kramer, A.B. University of North Carolina, 1975; M.E. North Carolina State University, 1976; Ph.D. University of California, Davis, "Participation in Farm Commodity Programs with Implications for the Changing Structure of Agriculture."
T. J. Lutton, B.A. Catholic University; M.S., Ph.D. University of Maryland, "An Analysis of Inter-Fuel and Inter-Factor Substitution in the Food Processing Sector."
A. Thieme, B.S. Texas Tech University; M.S. University of Idaho; Ph.D. University of Maryland, "A Simulation Approach to the Socio-Economic Analysis of the Foot and Mouth Disease Program."
M. H. Tracy, B.S. Cornell University; M.S., Ph.D. University of Maryland, "Agricultural Commodity Promotion: An Examination of the Egg Industry Check-off Program."
Jorge E. Moya Rodriguez, B.S. 1975, M.S. 1977, New Mexico State University; Ph.D. Mississippi State University, "Spatial Costs of an Integrated Broiler Firm as a Function of Plant Size, Location and Grower Density: A Case Study."
Albert O. Yeboah, B.A. University of Ghana, 1973; M.S. University of Guelph, 1975; Ph.D. University of Wisconsin, "An Aggregative Analysis of U.S. Agriculture: Impact of Farm Programs and Exogenous Changes."

Agricultural Finance, Capital, and Credit

Ahmed Humeida Ahmed, B.S. 1970, M.S. 1976, Khartoum University; Ph.D. Ohio State University, "Recent Performance of Rural Financial Markets in the Sudan, 1965–1979."
Robert Gene Aukes, B.S. 1974, M.S. 1977, Montana State University; Ph.D. University of Illinois, "Effects of Variable Amortization Plans on Borrower and Lender Risk: A Simulation Study of Low Equity Illinois Cash Grain Farms."
Girma Begashaw, B.S. Haile Selassie University, 1973; M.S. Michigan State University, 1976; Ph.D. Ohio State University, "Evaluation of a Supervised Credit Project in Jamaica."
Ivan Sergio Freire de Sousa, B/Licentiate, Pontifica Universidad de Sao Paulo, 1969; M.S. University of Sao Paulo, 1974; Ph.D. Ohio State University, "Accumulation of Capital and Agricultural Research Technology: A Brazilian Case Study."
Glenn D. Pederson, B.S. University of Minnesota, 1973; Ph.D. Michigan State University, "A Conceptualization and Analysis of the Distributional Impacts of Alternative Agricultural Credit Policies."
MD. Luthfor Rahman, B.A. Dacca University, 1962; M.S. 1966, Ph.D. Texas A&M University, "Variable Amortization and Financial Control under Uncertainty."
Luis Roberto Sanint, B.S. University of Los Andes, Bogota, Colombia, 1974; M.S. 1976, Ph.D. Texas A&M University, "Lenders' Credit Response to Farm Income Risks in Texas: A Multiperiod Risk-Programming Analysis of Credit Reserves."
Mohamed H. Takroni, B.S. University of Idaho; M.S. New Mexico State University; Ph.D. Oklahoma State University, "Evaluating Loan Repayment in the Saudi Arabian Agricultural Sector by Means of Farm Credit Interdependent System."

The names of Ph.D. recipients are provided by departments of agricultural economics and by departments of economics with majors in agricultural economics. The list is for degrees granted in the calendar year 1980, unless otherwise stated.

Fred Eugene Williams, B.S., M.E., Ph.D. North Carolina State University, "Capitalized Allotment Values as Indices of the Uncertainty with Which Farmers Perceive Future Tobacco Programs."

Agricultural Labor; Rural Manpower

Marietta S. Adriano, Ph.D. Purdue University, "The Impact of an Irrigation Project on Labor Intensity and the Distribution of Income: The Case of the Sibalom Irrigation Project in Iloilo, Philippines."
David Thomas Barker, B.S. New York State University, Brockport; M.E., Ph.D. North Carolina State University, "An Analysis of Short-run Changes in Retirement Behavior Using a Life-Cycle Model."
Juan Diez-Canedo-Ruiz, Lic., Instituto Tecnologico de Mexico, 1973; Ph.D. Massachusetts Institute of Technology, "A New View of Mexican Migration to the United States."
Thomas M. Dickey, B.S. Oklahoma State University, 1968; M.S. 1974, M.A. 1974, Ph.D. Michigan State University, "The Puerto Rico Wage Rate Subsidy for Agricultural Labor."
Teresa Jayme Ho, B.S. 1971, M.A. 1974, University of the Philippines; Ph.D. Stanford University, "The Labor Market for Married Women in the Rural Philippines."
Wuttithep Indhapanya, B.A. Thammasat University; M.E., Ph.D. North Carolina State University, "Some Aspects of Migration in the Philippines: An Empirical Model of Family Migration."
Winthrop Hubbard Segur, B.S. Trinity College, 1958; M.A. Bowdoin College, 1965; M.S. 1975, Ph.D. University of California, Davis, "Representative Elections for Farm Workers: Voting Power under Alternative Rules of Eligibility."

Agricultural Products: Demand, Supply, Prices

Shashanka Bhide, B.S. University of Agricultural Sciences, 1973; M.S. Indian Agricultural Research Institute, 1975; Ph.D. Iowa State University, "A Separable Programming Model Incorporating Linear Demand Functions for Grains and Vegetable Oils: An Analysis of United States Agriculture in 1985."
Steven C. Blank, B.A. California State College, Stanislaus; M.B.A. University of Massachusetts; Ph.D. University of Hawaii, "A Study of Futures and Cash Prices of Beef Cattle—Relating Theory to Fact for a Nonstorable Commodity."
Harlan N. Burnstein, M.S. 1975, Ph.D. Pennsylvania State University, "An Econometric Analysis of the Aggregate Acreage Response to Fluctuation in Farm Prices and Revenues."
Gurprit Chhatwal, B.S. Punjab Agricultural University, India; M.S., Ph.D. Kansas State University, "Distinctive Effect of P.L. 480 Wheat Imports for India."
Ashok Kumar Chowdhury, B.S. Govind Ballabh Pant University of Agriculture and Technology, 1973; M.S. Indian Agricultural Research Institute, 1975; Ph.D. Iowa State University, "Competitive Partial Equilibrium Analysis of U.S. Agriculture under Alternative Energy and Export Situations—Application of Separable and Chance Constrained Programming."
Roger Alan Dahlgran, B.S. Iowa State University; M.E., Ph.D. North Carolina State University, "Acreage Response to Government Pest Control Programs: The Case of Boll Weevil Eradication."
Christopher Douglas Easter, B.S. 1970, B.S. 1971, University of Newcastle Upon Tyne, England; M.S. 1978, Ph.D. University of California, Davis, "Supply Response with Stochastic Technology and Prices in Australia's Rural Export Industries."
J. R. Groenewegen, B.S. 1975, M.S. 1976, University of Guelph; Ph.D. University of Minnesota, "Corn and Soybean Acreage and Yield Response with Emphasis on Multiple Product Production, Uncertainty, and Commodity Programs."
John David Hanson, B.S. 1975, Ph.D. Iowa State University, "An Information Theory Analysis of Grades and Grading with an Application to Beef Cattle."
Apisith Issariyanukula, B.S. Kasetsart University, 1971; M.S. National Taiwan University, 1974; Ph.D. Washington State University, "An Econometric Analysis of the Supply and Demand for Soybeans in Thailand."
Thomas A. Loudat, B.A. University of California, Santa Barbara; M.S. California Polytechnic State University; Ph.D. University of Hawaii, "An Economic Analysis of the Competitive Position of the Hawaii Banana Industry in the Honolulu Market."
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Jeffrey W. Pyne, B.S. University of Wisconsin;

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M. H. Tracy, B.S. Cornell University; M.S., Ph.D. University of Maryland, "Producer-Financed Commodity Advertising: An Examination of the Egg Research and Promotion Program."

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Mark D. Newman, B.A. Pennsylvania State University, 1972; M.S. 1978, Ph.D. Michigan State University, "An Evaluation of the Economic Potential for Coordination of Export Marketing by U S. Farmer Cooperatives."

Buggaran Saragih, B.S. Bogor Agricultural University; M.E., Ph.D. North Carolina State University, "The Case of Oil Palm Plantations in Northern Sumatra, Indonesia."

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Valentine Jervis Akenda-Ondoga, B.S. Makerere University; M.S., Ph.D. Cornell University, "An Economic Study of Production Organization and Labor Use among Smallholders of Nile Province, Uganda."

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Harry Emil Brautigam, Lic. Universidad Autonoma de Guadalajara, 1971; Dipl. Victoria University of Manchester, 1973; M.A. University of Leeds, 1974; Ph.D. University of Illinois, "Analysis of Objectives of the Development of the Agricultural Frontier of Nicaragua."

Konstantinos Dimitrios Christou, Graduate, University of Salonika, 1970; M.S. 1976, Ph.D. University of California, Berkeley, 1979, "Greek Agricultural Development and Integration with European Communities."

Gary Peter Ender, B.S. Massachusetts Institute of Technology; M.S., Ph.D. Cornell University, "The Development of Road Transportation in Nepal and Its Relationship to Agricultural Development."

Marco Antonio Ferroni, Baccalaureat Kantonsschule Oblsalben, Demi-Lic. University of Geneva, Switzerland; M.S., Ph.D. Cornell University, "The Urban Bias of Peruvian Food Policy: Consequences and Alternatives."

M. T. Futa, B.S. University of Zaire; M.S. University of Florida; Ph.D. Oklahoma State University, "An Integrated Evaluation of Agricultural Research in Tropical Africa: Case of Nigerian Food Crops Research System."

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Zvi Ron, B.A. Tel Aviv University, 1971; M.S. Hebrew University of Jerusalem, 1976; Ph.D. Pennsylvania State University, "Agricultural Variation and Household Behavior: A Microeconomic Analysis of Human Fertility among Thai Rice Farm Families."

T. P. Sendjaja, B.S. Padjadjaran University; Ph.D. University of Tennessee, "Perspective Analysis of Small Community Capital Accumulation (PASCCA): A Model for Diagnosing Local Impacts of Agricultural Changes, with Applications to West Java Rice Villages."

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Sweder Jan-Gijsbert Van Wijnbergen, Kand (Phys.), Kand (Econ.), Rijksuniversiteit Utrecht, 1972; Ph.D. Massachusetts Institute of Technology, "Credit Policy, Inflation, and Growth in Less Developed Countries."
Vivianne Ventura-Dias, Architect, Mackenzie University, Sao Paulo, Brazil, 1967; M.C.P. 1975, M.S. 1978, Ph.D. University of California, Berkeley, "Small and Large Enterprises in the Brazilian Textile Industry: The Modernization of a Traditional Industry."
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Richard George Anderson, B.A. University of Minnesota, 1972; Ph.D. Massachusetts Institute of Technology, "Energy Conservation and Factor Substitution in U.S. Manufacturing 1947–1971."
M. A. Litterman, B.S. 1974, Ph.D. University of Minnesota, "Energy Substitution in U.S. Manufacturing and Agriculture."
Juvir Luiz Mattuella, B.S. 1968, M.S. 1974, Porto Alegra; Ph.D. Ohio State University, "Economic Impact of Alcohol Production on Agriculture in Southern Brazil."
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Margo Beth Rich, B.S. Cornell University 1973; Ph.D. Stanford University, 1979, "Residential Energy Conservation and Price Response."
Jeffery R. Williams, B.S. Pennsylvania State University, 1975; M.S. 1977, Ph.D. Michigan State University, "An Economic Analysis of the Feasibility of the Retort Pouch for Packaging Fruit and Vegetable Commodities in an Environment of Rising Energy Prices."

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Theodore Richard Frickel, B.A. University of Colorado, 1966; M.A. Northeastern University, 1975; Ph.D. Utah State University, "Economic Impacts of Irrigation Technologies in the Sevier River Basin."
Carl Christian Mabbs-Zeno, B.A. University of Connecticut 1974; M.S. University of Georgia, 1977; Ph.D. Virginia Polytechnic Institute and State University, "Institutional Purpose and the Management of Virginia's Coastal Wetlands."
William Claude Kinney, B.S. Stanford University, 1970; M.S. 1976, Ph.D. University of California, Davis, "Land-Use Conflict in Wildland Watershed Management: A Multiple Objective Economic Analysis."
William Mills Park, B.A. Depauw University, 1974; M.S. Purdue University, 1976; Ph.D. Virginia Polytechnic Institute and State University, "The Role of Benefit Taxation and Cost Sharing in Nonpoint-Pollution Management."
Ricardo Rodriguez-Dorbecker, Lic. en. Economia, Esc. Nal. de Economia; M.S. Centro de Economia Agricola; Ph.D. North Carolina State University, "Acreage Response to Government Pest Control Programs: The Case of Boll Weevil Eradication."
Webb Morrow Smathers, Jr., B.A. University of North Carolina, Ashville, 1970; B.A. 1972, M.S. 1974, Ph.D. University of Kentucky, "A Mixed Integer Method for Analyzing the Impact of Surface Mining Regulations on Economies with Public and Private Goods."
David Zilberman, A.B. Tel Aviv University, Israel, 1972; Ph.D. University of California, Berkeley, "A Putty Clay Approach to Environmental Quality Control."

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R. Hinson, B.S., M.S., Ph.D. University of Tennessee, "Household Budget Allocation: The Interrelationship between Fixed Expenses and the Purchase of Food."
Anne Margaret Thomson, B.A. Cambridge University, England, 1972; Ph.D. Stanford University, "Nutrition, Food Demand and Policy."

Industrial Organization; Market Structure

Ella Kay Carl, B.A., M.A., M.A.M.R.D., Ph.D. University of Florida, "Selection of Alternate Vertical Exchange Mechanisms and Its Effects on Market Price."
Wilson C. Chase-Lansdale, A.B. Harvard University, 1974; Ph.D. Michigan State University, "The Political Economy of Farmer Bargaining: Cooperative and Proprietary Processor Responses to Farmer Bargaining."
Peter W. Philips, B.A. Pomona College, 1970; M.A. 1977, Ph.D. Stanford University, "Towards a Historical Theory of Wage Structures: The Evolution of Wages in the California Canneries—1870 to the Present."

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Bruce L. Anderson, B.S. Cornell University, 1968; M.S. Purdue University, 1972; Ph.D. University of

California, Berkeley, "The Economic Potential of Cooperative Integration in the California Cotton Industry."
Kim B. Anderson, B.S., M.S., Ph.D. Oklahoma State University, "Coordinative Efficiency of Grades and Standards for Feeder Cattle."
Colin Andre Carter, A.B. 1975, M.S. 1976, University of Alberta; M.A. 1978, Ph.D. University of California, Berkeley, "Grain and Oilseeds Futures Markets: Portfolio and Efficiency Analyses."
Lowell Bee Catlett, B.S. West Texas State University, 1973; M.S. New Mexico State University, 1975; Ph.D. Iowa State University, "Commodity Options as an Alternative to Hedging Live Cattle."
Kareko M. Gatere, B.S. 1972, M.S. 1974, Makerere University; Ph.D. University of Alberta, "Market Efficiency in Kenya: A Study of the Marketing System for Fruits and Vegetables."
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Linwood Allen Hoffman, B.S. 1970, M.S. 1972, Pennsylvania State University; Ph.D. University of Illinois, "The Economic Effects of Demand-Sensitive Railroad Rates upon the Storage and Transportation System for U.S. Feed Grains."
Christopher Allan Hurt, B.S. University of Illinois, 1971; M.S. Cornell University, 1973; Ph.D. University of Illinois, "Impact of Price Risk on Aggregate Farrowing Response."
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Philip Woodrow Pepper, B.S. 1970, M.S. 1974, Mississippi State University; Ph.D. University of Illinois, "A U.S. Corn Stocks and Consumption Demand Model."
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Stephen P. Skinner, B.A. Central Connecticut State College, 1972; M.A. University of Rhode Island, 1975; Ph.D. University of Connecticut, "Production Response and Structural Change in the Connecticut, Massachusetts and New Hampshire Egg Industries Resulting from Adjustments in the Level of Freight Rates."
Peter Kristian Thor, B.S. 1976, M.S. 1977, Ph.D. University of California, Davis, "An Economic Analysis of the Marketing Orders for the California-Arizona Orange Industry."
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Donald Ray Andrews, B.S. Southern University, 1971; M.S. University of Florida, 1974; Ph.D. Texas A&M University, "Economic and Fiscal Impacts of Lignite Development for the Brazos Valley Economy of Texas."
Nancy Theresa Gallini, A.B. 1973, M.A. 1974, University of Missouri; Ph.D. University of California, Berkeley, "Research and Development of an Exhaustible Resource Substitute: The Case Study of Synthetic Oil."
Ronald C. Griffin, B.A. 1975, M.A. 1977, Colorado State College; Ph.D. University of Wisconsin, "Irrigated Agriculture and Nitrate Pollution of Rural Water Supplies: Economics for Policy in Central Wisconsin."
Thomas Parkin Hunter, B.S., B.A. University of the South; M.S., Ph.D. North Carolina State University, "The Geographic Variation of Southern Pine Timber Prices."
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Sumol Padungchai, B.S. Chulalongkorn University, 1973; M.S. 1975, Ph.D. Utah State University, "An Economic Analysis of Water Quality Improvement Policies: The Optimal Combination of Salinity Control Techniques."
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Gordon Roy Banta, B.S. 1963, M.S. 1967, Ph.D. University of Alberta, "Asian Cropping Systems Research: Micro-Economic Evaluation Procedures."
Jose Baldeci Biserra, Diploma of Engineer Agronomo, Universidade Federal do Ceara, Fortaliza, 1969; M.S. Universidade de Sao Paulo, Piracicaba, 1971; Ph.D. Ohio State University, "Uncertainty and Decision Analysis on Large Sharecropped Farms in Northeast Brazil."
Angus Chidebelu, B.S. University of Nigeria; M.S. University of Guelph; Ph.D. University of Georgia, "An Analysis of Factors Affecting the Commercialization of Limited Income Farms in Georgia."
Eric Winthrop Crawford, B.A. Pomona College; M.P.A. Woodrow Wilson College; Ph.D. Cornell University, "A Programming-Simulation Study of Constraints Affecting the Long-Run Income-Earning Ability of Traditional Dryland Farming Systems in Northern Nigeria."
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Sushma Sharma Ganguly, B.A. 1969, M.A. 1971, University of Delhi; M. Phil. Jawaharal Nehru University, 1976; Ph.D. Clemson University, "A Risk-Return Analysis of Irrigating Field Crops in South Carolina."
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Thomas J. McGuckin, B.A. Pomona College, 1972; M.S. Colorado State College, 1976; Ph.D. University of Wisconsin, "An Economic Assessment of Alfalfa Dewatering Technology in Wisconsin."
Ndanusa Braimah Mijindadi, B.S. Ahmadu Bello University; M.A. University of Leeds; Ph.D. Cornell University, "Production Efficiency of Farms in Northern Nigeria."
Arun Kumar Misra, B.S. 1963, M.S. 1965, Orissa University of Agriculture and Technology; Ph.D. University of Missouri, "An Economic Evolution of Problems and Production Potentials of Small Farms in Orissa, India."
Abdoulaye Niang, Ph.D. Purdue University, "A Linear Programming Model of a Representative Sahelian Farm: The Cases of the Cotton Zone in Mali and the Peanut Zone in Senegal."
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Abraham Ovedṭji Ogungbile, B.S. Western Illinois University, 1972; M.S. University of Missouri, 1974; Ph.D. Iowa State University, "An Evaluation of Improved Sole-Crop Production Technology on Small Farms in Northern Nigeria under Different Farm Power Sources: A Multi-period Linear Programming Approach."
Tillak Persaud, B.S. University of Illinois; M.S. University of Idaho; Ph.D. Oklahoma State University, "Decision Making Relating to Risk Management Strategies in a Farm Planning Model."
James Alfred Petty, B.S. Abilene Christian College, 1957; M.S. Texas Tech University, 1970; Ph.D. Texas A&M University, "Impact of Alternative Energy Prices, Tenure Arrangements and Irrigation Technologies on a Typical Texas High Plains Farm Firm."
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Rafael Posada, Ph.D. Purdue University, "The Impact of the High Yielding Varieties on the Import Requirements of the LDC's: The Case of Wheat."
Michael Robert Rahm, B.A. Loras College, 1975; M.S. 1978, Ph.D. Iowa State University, "An Economic Analysis of the Corn Production Efficiency at Iowa Farm Firms."
Carlos Sevilla, B.A. University of Hawaii, 1970; M.A. 1972, Ph.D. Stanford University, "A Microeconomic Study of Corn Production in Guatemala."
Charles Cameron Short, B.A. 1971, M.S. 1976, University of British Columbia; Ph.D. Iowa State University, "Groundwater Mining in the Ogallala Aquifer in Relation to Rising Energy Prices and Agricultural Production."
William D. Shurley, Ph.D. Purdue University, "Production, Marketing, and Storage Decisions under Risk for Cash-Grain and Crop-Hog Farms in West-Central Indiana."
Evelyn C. Spears, B.S. Arizona State University,

1970; M.S. Michigan State University, 1977; Ph.D. Texas A&M University, "An Economic Model for Planning Combination Small Stock-Cattle Herd Development: An Application to Edwards Plateau, Texas."

Kenneth Wayne Stockes, B.S. 1967, M.S. 1969, Texas Tech University; Ph.D. Texas A&M University, "Economics of Alternative Beef Genotypes and Cattle Management/Marketing Systems."

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John Patrick Warren, B.S. Oklahoma State University, 1969; M.S. 1974, Ph.D. Texas A&M University, "The Texas Bay Shrimp Industry: A Description and Management Model."

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Joyce Elaine Allen, B.S. North Carolina Agricultural and Technical University, 1974; M.S. North Carolina State University, 1976; Ph.D. University of Illinois, "An Analysis of the Food Stamp Program: Policy Decisions and Household Food Expenditure Patterns."

Edinaldo Gomes Bastos, B.A., M.A. University of Federal de Pernambuco; Ph.D. Cornell University, "Farming in the Brazilian Sertao: Social Organization and Economic Behavior."

Wu-Hsiung Chen, B.S. 1966, M.S. 1970, Chung-Hsing University; Ph.D. University of Illinois, "An Economic Study on Government Rice Stock Operation in Taiwan."

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J. R. Groenewegen, B.S. 1975, M.S. 1976, University of Guelph; Ph.D. University of Minnesota, "Corn and Soybean Acreage and Yield Response with Emphasis on Multiple Product Production, Uncertainty, and Commodity Programs."

Patricia Hutton, B.S.A. University of Manitoba, 1974; M.A., Ph.D. University of Wisconsin, "U.S. Dairy Policy: A Quantitative Analysis of the Post World War II Period."

Duane L. Marquis, B.S., M.S. University of Nebraska; Ph.D. Oklahoma State University, "Value of Improved Forecast Information from a Satellite-Based Crop Information System"

Eric A. Monke, B.A. 1974, Williams College; Ph.D. Stanford University, "Government Policy and International Trade in Rice."

William Palmer Patton, B.A. 1975, M.A. 1976, Texas Tech University; Ph.D. Texas A&M University, "The Impact of the 1977 Food and Agriculture Act on Cotton Production in the United States."

Anne Margaret Thomson, B.A. Cambridge University, England, 1972; Ph.D. Stanford University, "Nutrition, Food Demand and Policy."

Regional, Rural and Community Development

Syed Aljunid, B.A. University of Malaya, 1970; M.A. New York State University, 1972; Ph.D. University of Wisconsin, "Land Fragmentation and Share Tenancy; Some Issues in Malaysian Land Reform—With Particular Reference to Padi Farming in the Kemubu Irrigation Project in Kelantan."

Jack W. Craven, B.A. University of Manitoba, 1970; M.A. York University, 1972; Ph.D. University of Manitoba, "The Role of Transportation in Regional Development: Impacts on Industrial Location."

German Escobar, B.S. Santo Tomas University, 1970; M.S. Cornell University, 1975; Ph.D. Oregon State University, "Prospects for Technical Change and Family Nutrition Effects in the Caqueza Integrated Rural Development Project of Colombia: An Economic Evaluation under Risk."

John Gerweck, M.S. 1975, Ph.D. Pennsylvania State University, "Factors Affecting National Health Service Corps Retention."

Helen H. Jensen, B.A. Carleton College 1968; M.S. University of Minnesota 1974; Ph.D. University of Wisconsin, "Financing Health Care in Rural Areas."

D. J. Leuck, B.S., M.S. Purdue University; Ph.D. University of Tennessee, "A Cross-Sectional and Time-Series Model of Multi-Industry Employment in Rural Tennessee Counties."

Barry Primm, B.A. Graceland College; M.S., Ph.D. Kansas State University, "An L. P. Simulation Analysis of Agricultural and Rural Development of the Northwestern Kansas Counties of Decatur, Rawlins and Sheridan."

Harjinder Sandhu, Ph.D. University of Massachusetts, "Valuation of Social Benefits of Planned Development: An Application of Metropolitan Landscape Planning Model."

Donald LeRoy Snyder, B.S. 1972, M.S. 1973, University of Wyoming; Ph.D. Utah State University, "An Analysis of the Optimal Allocation of Output in a Regional Setting: A Theoretical and Empirical Approach."

S. Tun, B.S., Ph.D. University of Tennessee, "An Empirical Selection of Counties and Centers that Reflect Potential for Further Growth in Nonmetropolitan Areas in Tennessee."

Research Methodology

Eduardo S. Canlas, B.S. 1961, M.A. 1972, Xavier University, Philippines; Ph.D. Ohio State University, "A Comparative Analysis of the L.P. and

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Timothy Gordon Taylor, B.A. University of Cincinnati; Ph.D. University of Florida, "A Bio-Econometric Analysis of the Gulf of Mexico Commercial Reef Fish Fishery."

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Sector and Subsector Analysis

Michael Joseph Ellerbrock, B.S. Texas A&M University, 1974; M.S. 1975, Ph.D. Clemson University, "Prices and Pricing in the Hotel/Motel Industry in South Carolina: An Econometric Analysis."

Henry Sessam Foster, Jr., B.S. U.S. Military Academy, 1966; M.S. 1977, Ph.D. Texas A&M University, "The Estimation and Use of a Quadratic Input-Output Model for Macroeconomic Analyses of the U.S. Economy."

Mohamoud Awaleh Gulaid, B.S. 1972, M.S. 1975 University of Wyoming; Ph.D. University of Illinois, "Economic Tradeoffs between Foodgrain and Banana Production in Somalia."

Dean Winston Hughes, B.S. Princeton University, 1972; M.S. Purdue University, 1975; Ph.D. Texas A&M University, "A General Equilibrium Model of Agriculture as Part of the United States National Economy."

J. Mandagi, M.S. 1976, Ph.D. University of Minnesota, "A Simulation Model for Indonesia with Economic Projections and Regional Distribution of Growth from 1972 to 1985."

Manuel Mondragon Manuel, Jr., B.S. 1962, M.S. 1969, University of the Philippines, Los Banos; M.S. University of Hawaii, 1975; Ph.D. University of Idaho, "An Econometric Model to Measure the Impact of Expanding Irrigation in Southwestern Idaho."

Clair Johnson Nixon, B.S. Brigham Young University 1975; M.S. 1977, Ph.D. Texas A&M University, "Measurement of Texas Livestock Capacity and Its Effect on the Texas Economy."

Samih K. Staitieh, B.S. 1973, M.S. 1975, American University of Beirut; Ph.D. Washington State University, "Economic Impacts of Changes in the Salmon-Steelhead Fishing Sector in the Pacific Northwest."

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John A. Mapes, B.S. Cornell University; M.S., Ph.D. University of Hawaii, "Simulated Income Distributional Impacts of Immigration: A Case Study of Hawaii."

Anthony Tadashi Nakazawa, A.B. University of Hawaii, 1971; M.A. University of California, Santa Barbara, 1974; Ph.D. University of California, Berkeley, 1979, "Consumer Preferences for Housing by Tenure and Structure Type."

Bernard Daniel Pillet, B.A. ENSIA, France, 1965; M.S. Cornell University, 1967; Ph.D. Stanford University, "Fertility Changes in the Early Decades of Rapid Socioeconomic Development: A Statistical Description of the Recent Mexican Experience."

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John Antle, B.A. Albion College, 1976; M.A., Ph.D. University of Chicago, "Human Capital Infrastructure and Technology Choice in Agricultural Development."

Gustavo Arcia, B.S. 1974, M.S. 1975, University of Florida; Ph.D. University of Missouri, "Risk, Institutional Change and Technology Adoption for Low Income Farmers: An Analysis of New Bean Alternatives for the Southern Huila Region of Colombia, South America."

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Other

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Editor's Note:

The editors apologize for the incorrect placement of the figures in Oscar Burt's article, "Farm Level Economics of Soil Conservation in the Palouse Area of the Northwest," in the February issue of the *Journal*.

The correct placement and captions should be:

Figure 3 should have been labeled figure 1, with the caption: "Decision rule with wheat at \$3.20 per bushel (percent of land in wheat)"

Figure 2 should have been labeled figure 3, with the caption: "Marginal values of organic matter with wheat at \$3.20 per bushel"

Figure 1 should have been labeled figure 2, with the caption: "Decision rule with wheat at \$3.20 per bushel"

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Articles

Effects of an Export Embargo on Related Goods: Logs and Lumber

A. Clark Wiseman and Roger A. Sedjo

This paper extends and applies the Marshallian derived demand model in the context of international trade. The model is utilized to derive estimates of the market equilibrium, net welfare, and welfare incidence effects of a hypothetical embargo of softwood log exports from the Pacific Coast region of the United States. The approach is potentially applicable to the analysis of various restrictions on primary products exports which may be instituted to maintain the viability of domestic processing industries.

Key words: export embargo, forest products trade, trade policy.

This paper estimates the efficiency and distributional effects of a hypothetical total embargo of softwood log exports from the Pacific Coast region (Washington, Oregon, and California). The issue is of considerable practical interest: restrictions, including an embargo on logs produced on federal lands in the region, have been in effect for more than ten years, and congressional hearings (U.S. Congress) periodically examine additional restriction options, including extending the scope of the embargo to logs from private lands. Discussions and analyses of the log export issue, including Haynes (1976) and Wiener, have yielded diverse opinions and estimates of present and potential effects, including conjecture on the extent of the "feedback" of increased foreign demand for processed domestic wood products resulting from foreclosure of the raw material source. In the following, limits to the extent of this potential feedback are identified and estimates of effects of log export prohibition are made for two limiting cases. Price and output effects and incidence of welfare impacts upon affected groups within the Pacific Coast region (PCR) are estimated for the two cases.

Paarlberg and Thompson have used a multiproduct partial equilibrium model to analyze the effect of a tariff when goods are related. However, the relationships in their model consist of nonzero cross-price elasticities of demand, rather than relatedness in production. Dardis carried out an analysis of gains from trade using a model that included an intermediate good and final product. The analysis did not employ an explicit derived demand model, and was limited to the small country (price taker) case. A small-country partial equilibrium model was also employed by Bautista in a study of effects of exchange rate changes on prices of a primary good and a processed commodity using the primary good as an input. Because fixed stocks of the goods were assumed, supply side impacts were not included in the analysis. The forest economics literature recognizes that the demand for logs is derived from the demand for lumber; however, an analysis that explicitly integrates the two markets is not available. Haynes, for example, deals only with the demand side of the markets and uses the "marketing margin" concept (Tomek and Robinson) as constituting a stumpage-lumber price spread (Haynes 1977).

The theoretical basis for the present analysis is an extension of Marshall's derived demand model under fixed factor proportions. The approach allows the simultaneous treatment of the primary (log) market and the market for the final product (lumber) and provides a straightforward means of assuring that consistency is maintained between markets. The methodology developed may be useful for analyzing the implications of other restrictions ostensibly designed to promote processing industries or to maintain low domestic final

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The authors are, respectively, an associate professor of economics, Gonzaga University, and Senior Fellow, Resources for the Future.

This research was undertaken as part of the Forest Economics and Policy Program of Resources for the Future.

product prices. The principal focus of this analysis is upon efficiency and distributional implications. The model is extended to include estimates of the welfare incidence in terms of Marshallian surplus measures for three affected groups—owners of factors employed in the primary good industry (log production), owners of factors in the value-added or processing industry, and purchasers of the final product (lumber). Also, because of U.S. dominance in world softwood log markets, the analysis abandons the small country assumption of exogenous prices of both primary and final products.

In the next section, we briefly review current legal restrictions on U.S. log exports and describe the role of the Pacific Coast region (PCR) in log and lumber markets. Next, we illustrate the basic model and the theoretical effects of a log export embargo, then discuss the empirical application of the model. And, finally, we give results and draw conclusions.

Background

Since 1974, the U.S. government has prohibited the export of softwood logs from federally owned land (under U.S. Forest Service and Bureau of Land Management administration) west of the 100th meridian. Prior to that, from 1969 through 1973, the ban was partial, limiting log exports from federal lands to a maximum of 350 million board feet per year. As with other countries having similar restrictions, the basic intent of the legislation is to maintain a low price of the basic raw material input into the forest products industries, and, hence, protect domestic processors from the cost-increasing effect of log export trade.

The United States produces about 30% of the world's softwood saw and veneer logs, and is its major exporter of softwood logs, accounting for almost 50% of world exports. U.S. exports come almost exclusively from the PCR, where in recent years annual log exports have been about 2,500 million board feet, or 15%–20% of total PCR softwood log production. Over 95% of the PCR log exports go to East Asia, primarily to Japan and Korea. Exports of logs from the PCR to other U.S. regions are negligible.

Although the United States produces about 20% of the world's softwood lumber, its gross exports constitute only about 8% of total world exports. Indeed, the United States is a net importer of softwood lumber, its gross imports accounting for about 30% of the world's total. During the mid-1970s the PCR produced over 50% of the total U.S. production of softwood lumber. Only about 5% (about 800 million board feet in 1976) of the PCR lumber production was exported internationally. In 1976, about 25% of international softwood lumber exports of the PCR went to Japan, 12% to Canada, and the remainder to various other countries including almost 40% to western European countries. In addition, net regional "exports" to other areas of the United States constituted about 30% of the region's total lumber production.

The U.S. log export controls appear to have been a reaction to the large and rapidly growing volume of log exports to Japan, experienced in the 1960s. The percentage of the Washington and Oregon timber harvest going to Japan as logs rose every year between 1962 and 1970, going from about 2% to 16% over the period. The large growth in Japanese demand for wood resulted largely from a very high rate of economic growth in that country, accompanied by a prolonged housing boom. The tendency of the Japanese to rely heavily on log imports rather than on imported lumber reflected Japan's comparative advantage in labor-intensive, wood-processing activities augmented by Japanese trade policies directed toward the protection of the processing industries. In addition, the wide variety of specifications and widespread customization of lumber required by traditional Japanese construction methods do not readily lend themselves to lumber having U.S. standardized specifications.

A Log/Lumber Trade Model

In this analysis it is assumed that ordinates of the relevant supply and demand functions represent the private and social marginal rates of transformation in production and consumption, respectively. Accordingly, the conceptual model developed in this section will employ long-run supply and demand functions in the assumed absence of technological externalities. All estimates of elasticities used in empirical estimation in the next section are also long run, in order to avoid various short-run problems such as unemployment and excess capacity, capacity constraints, and inventory changes. "Processing" is an input which,

together with the homogenous raw material input, logs, is used to produce the finished homogenous product, lumber. It is assumed that both the composite input "processing" and the input "logs" are supplied by competitive industries subject to increasing costs, and that lumber production requires fixed proportions of the two inputs.

Let $l = a_1L$ and $r = a_2L$, where l is quantity of logs, L is quantity of lumber, r is quantity of processing and the a_i are input-output coefficients. For convenience, define an arbitrary quantity L_0 of lumber as a "unit," and the quantity a_iL_0 of the input as a "unit" of the input, so that a "unit of logs" and a "unit of processing" are defined as the respective amounts of the inputs required to produce a unit of lumber. This procedure allows a convenient diagrammatic representation of both the log and lumber markets simultaneously.[1]

In figure 1, D_L represents the PCR own-demand for lumber. Denote the "rest of world" (ROW) effective demand function for PCR lumber (not shown in figure) as D_L^F. This excess demand of other regions is "effective" in the sense of being net of transportation-related costs, tariffs, etc. Addition of D_L^F to D_L horizontally yields the function $D_L + D_L^F$, the total demand for PCR lumber.[2] Subtracting the processing supply function (not shown) vertically from $D_L + D_L^F$ gives D_l, the demand for PCR logs given the existence of lumber trade.

To illustrate, if the price of lumber is P_2, P_2e units of PCR lumber are demanded, of which de is export demand. The supply price (cost) of the processing industry at output P_2e is distance ve, so that at P_2 the demand price of the P_2e units of logs demanded is P_2 minus ve, or R_2.

The PCR supply function of logs is shown as S_l in figure 1. The vertical addition to this of the processing supply function gives S_L, the PCR supply curve of lumber given no log trade.[3] Denote the ROW effective demand function for PCR logs as D_l^F. Subtracting D_l^F horizontally from S_l gives $S_l - D_l^F$, the supply

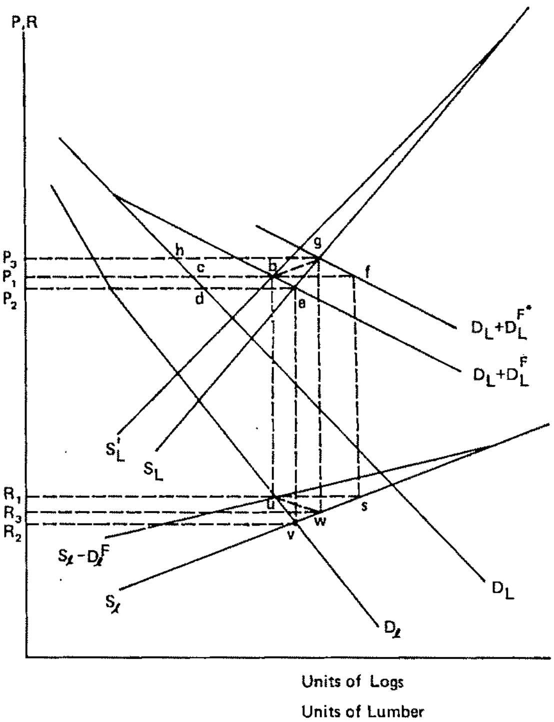

Figure 1. Market equilibrium and effects of log export embargo for a region exporting both logs and lumber

function of logs to the PCR, given the existence of log trade.[4] Addition of the supply function of processing vertically to $S_l - D_l^F$ yields S'_L, the PCR supply function of lumber, given trade in logs.

An "initial" equilibrium where the PCR is an exporter of both logs and lumber is depicted at prices P_1 and R_1. At the equilibrium log price R_1, production of logs is R_1s. Of this, su is exported and R_1u is processed in the PCR at cost ub; cb units of lumber are exported at price P_1, and P_1c consumed in PCR.

The effects of a total log export embargo by the PCR are also shown in figure 1. As a limiting case, it is first assumed that the ROW demand function D_L^F is not affected by log market changes. Later, a second limiting case is discussed which allows for feedback effects on the ROW lumber market resulting from the imposition of a log embargo.

Effects of Log Export Embargo: No Feedback in Lumber Market

In the case of no feedback of increased foreign demand for PCR lumber resulting from a log

[1] Gardner notes (p. 407) that the derived demand model under fixed factor proportions can be analyzed by graphical methods. The presentation employed here will be entirely diagrammatical.

[2] Were the region a net importer of lumber, the same basic derivation would apply, except that an ROW-effective lumber supply function would be subtracted from D_L to obtain total demand for PCR lumber.

[3] To avoid unnecessary graphical complications, the analogous derived demand for logs given no lumber trade is not shown; S_L is depicted because of its relevance in the later analysis.

[4] Continuing the point of note 2, appropriate modification of the same model could depict the case of a log-importing region.

export embargo, the embargo would result in an equilibrium in the PCR log market at the point v. All logs are processed at cost ve. As compared to the initial equilibrium, lumber exports increase to de units, and PCR consumption increases at the lower lumber price to P_2d. The loss of economic rent to producers of logs is equal to the area R_1svR_2, and the gain in buyers' surplus to buyers of PCR logs is R_1uvR_2. This surplus consists of gains to both buyers and processors of PCR lumber. The area P_1beP_2 is the consumers' surplus gain to lumber buyers, and it can be shown that the difference between R_1uvR_2 and P_1beP_2 represents the increase in producers' surplus (rent) of the processing industry. Of the lumber consumers' surplus, P_1cdP_2 is gain to PCR buyers, and the remaining area $cbed$ is the gain of ROW buyers.

In summary, if the ROW demand for PCR lumber is independent of log sales to the ROW, a log export embargo will reduce both the price of logs and lumber in the PCR. Welfare losses in the region will exceed the welfare gains by the sum of the areas uvs and $cbed$ in figure 1. Distributionally, the prohibition would result in losses to log producers and gains to domestic processors and buyers of lumber. Some of the total gain to buyers will accrue outside the PCR.

Effects of Log Export Embargo: Maximum Feedback in Lumber Market

If there is interdependence between ROW log and lumber markets, the effect of a log export ban would be an outward shift in D_L^F. The amount of the shift will determine the amount of the increase or decrease in lumber and log prices and will affect the magnitude of welfare effects. The shift could result from increases in residual lumber demands in the nonwestern United States and Japan. That is, it could be caused by the direct influence of the increased demand for PCR lumber by the former major log importer, Japan, or an increased demand for PCR lumber from other areas (primarily, the non-PCR United States) whose former lumber supply from Canada is partially diverted to Japan.

The maximum increase in demand for PCR lumber that could occur as a result of a log export embargo would be an increase equal to the equivalent amount of logs formerly exported to ROW.[5] This demand shift is shown in figure 1 by the function $D_L + D_L^{F^*}$ through the point f, where $bf = su$. The equilibrium in this case is at prices P_3 for lumber, R_3 for logs, and processing price equal to distance wg. In comparison with the earlier limiting case of no feedback, the decline in log price is less, and lumber price rises rather than falls.

The distributional impact in this case also may be analyzed, where again the comparison is with the initial situation. The loss to owners of resources employed in log production is R_1swR_3. The gain to owners of resources employed in the processing industry is R_1uwR_3 plus P_1bgP_3.[6] These two areas represent, respectively, the gains to the processing industry from purchasing more logs at a lower price and from selling more lumber at a higher price. The loss to consumers in the PCR is P_1chP_3. The imposition of the log export ban in this case may result in a net welfare gain for the region, the net gain illustrated in figure 1 being $hgbc$ minus usw.[7]

The general theoretical results in the limiting cases may be summarized as follows. For any feasible theoretical feedback effect, the price and production of logs will fall, and owners of resources in log production will sustain losses. The reverse will be true for the processing industry which experiences gains in both limiting cases. Regional buyers will gain or lose, depending on the potential price-increasing impact of the feedback effect on lumber demand. The region as a whole may realize a net welfare gain or loss, depending upon the size of this feedback.

Empirical Analysis

Table 1 gives the estimated elasticities that were used in calculating market changes and

[5] This result can be demonstrated by a modification of the present model representing the production, trade, and consumption equilibrium of a region, i.e., Japan, that is both a log and lumber importer. Foreclosing the region's supply of logs from PCR will shift the region's excess demand function for lumber horizontally outward by the equivalent amount of logs formerly imported. Realistically, the shift in foreign demand facing each of the several lumber-exporting regions will be less than this total shift. The text takes as one limiting case (equivalent to the two-country case) that where the entire "feedback" effect of the embargo is upon the PCR.

[6] It can be shown that the segment bg is a portion of the processing supply function shifted vertically by the constant R_1.

[7] A net domestic welfare increase as a result of intervention with free trade is a theoretical possibility when the intervention has a terms-of-trade effect.

Table 1. Elasticity Estimates Used in Calculating Effects of Log Export Embargo

Function	Base Elasticity	Alternative Elasticity
D_L	−.35	−1.00
S_L	.44	1.00
S_l	.21	.48
D_L^F	−15.45	−9.19
$D_L + D_L^F$	−3.52	−40.00
D_l	−1.09	−2.16
Processing supply	4.23	5.50

welfare effects resulting from an export ban. In addition to the base estimates, an alternative was considered in order to examine the sensitivity of the results to different elasticity estimates. The base elasticities of D_L and S_L are long-run estimates developed by the U.S. Forest Service (USFS) for its "Timber Assessment Model" (U.S. Forest Service Pacific Northwest Forest and Range Experiment Station). The alternative values of D_L and S_L—both unity—are based on Haynes' (1976, p. 7) summary statements regarding earlier estimates. It should be noted that the base estimates are derived from a more recent and comprehensive analysis than those underlying the alternative estimates. All other elasticities were calculated by utilizing the USFS estimates, constraints imposed by the model itself, and other data on price and quantity relationships.[8] Because all but two of the functions in figure 1, D_L and S_l, are derived from others, even a limited knowledge of elasticities, along with market prices and quantities, allows calculation of required values of all other elasticities.

For example, it can be shown that for a given level of output,

$$ES_p = \alpha \bigg/ \left(\frac{1}{ES_L} - \frac{(1-\alpha)}{ES_l}\right),$$

where ES_p, ES_L, and ES_l are elasticities of supply of processing, lumber, and logs, respectively, and α is value added of processing per unit of lumber. Therefore, an estimate of the value of two of the elasticities and the processing margin, α, is sufficient to yield an estimate of the other elasticity. A similar relation holds on the demand side.

It was not necessary to estimate the elasticity of $S_l - D_l^F$. Under a log export embargo, equilibrium in the log market occurs at a point on S_l determined by lumber market conditions. The function $S_l - D_l^F$ together with S_l theoretically determine the disposition of PCR log production between exports and domestic processing (points s and u in fig. 1). However, in the actual estimation, market price, production, and export data were utilized to obtain points s and u.

The data base utilized in obtaining empirical estimates is from 1976, a year during which we assume the effect of the existing restrictions on log exports to be small. Accordingly, the data are assumed to reflect a regime free of effective log export restrictions. Actual data on prices and quantities and the information in table 1 are sufficient to generate consistent estimates of price and quantity changes for both logs and lumber, as well as welfare gains and losses to various groups in the limiting cases of maximum feedback effect and no feedback effect. Linear forms were assumed for all functions over the range of values analyzed. Details of calculation are not elaborated here.

Results and Conclusions

Estimates of the market equilibrium effects are given in table 2 and the corresponding welfare effects in table 3. The predicted changes in lumber price in the two cases are quite small, both in an absolute sense and relative to the log price changes. This result is interesting because the restrictionist argument is that the prohibition of log exports would result in a substantial reduction of lumber prices within the United States. Indeed, depending upon the degree of feedback, export restrictions actually may increase domestic lumber prices. In either case, domestic lumber sales would be affected only slightly.

Notice that both limiting cases yield a net regional welfare loss. The owners of resources devoted to log output will experience substantial net losses, given any feasible feedback, while owners of resources engaged in processing will experience substantial net gains. The size of these gains is relatively insensitive to the degree of feedback. Since purchasers of

[8] Data sources were Bergvall, Bullington, Gee (1976); Haynes (1976); Howard and Hiserote; Ruderman; U.S. Bureau of the Census; U.S. Department of Agriculture. No extraneous estimate of the elasticity of D_L^F is available. It was calculated on the assumption that ROW own-lumber demand and supply elasticities have the same values as those estimated for the PCR.

Table 2. Estimated Effects on PCR Log and Lumber Markets Resulting from Complete Log Export Embargo

	No Feedback of Foreign Lumber Demand in PCR Lumber Market		Maximum Possible Feedback of Foreign Lumber Demand in PCR Lumber Market	
	Percentage Change	Absolute Change[a]	Percentage Change	Absolute Change[a]
Base Estimate				
Log market				
Price	−12.0	−$22.80	−3.7	−$7.00
Quantity				
Production	−4.0	−580	−1.2	−175
Domestic sales	+13.1	+1,620	+16.3	+2,012
Exports	−100.0	−2,200	−100.0	−2,200
Lumber market				
Price	−3.7	−$7.70	+.4	+$.80
Quantity				
Production	+13.1	+2,140	+16.3	+2,660
Domestic sales	+1.3	+170	−.2	−20
Exports	+57.5	+1,970	+92.4	+2,680
Alternative Estimate				
Log market				
Price	−6.3	−$12.00	−3.1	−$5.90
Quantity				
Production	−3.6	−520	−1.8	−260
Domestic sales	+13.5	+1,670	+15.7	+1,940
Exports	−100.0	−2,200	−100.0	−2,200
Lumber market				
Price	−1.5	−$3.00	+.2	+$.50
Quantity				
Production	+13.5	−2,200	+15.7	+2,560
Domestic sales	+1.5	+190	−.1	−10
Exports	+58.7	+2,010	+75.1	+2,570

Note: Basis of comparison is current regime of tariff and other trade barriers, but with no U.S. log export restrictions. The estimates reflect 1976 conditions and prices.
[a] Quantity is millions of board feet for lumber and millions of board feet log-scribner scale for logs. Price is dollars per thousand board feet of the respective scales. Lumber and log scales are not equivalent.

Table 3. Estimated Annual Welfare Effects on PCR Market Participants Resulting from Complete Log Export Embargo (millions of dollars)

	No Feedback of Foreign Lumber Demand in PCR Lumber Market	Maximum Possible Feedback of Foreign Lumber Demand in PCR Lumber Market
Base Estimate		
Owners of resources employed in PCR		
log production	−209.8	−66.2
processing logs to lumber	+60.3	+76.2
PCR purchasers of lumber	+99.5	−10.9
Net welfare gain to PCR	−50.0	−.9
Alternative Estimate		
Owners of resources employed in PCR		
log production	−109.5	−53.9
processing logs to lumber	+42.4	+57.8
PCR purchasers of lumber	+39.2	−5.9
Net welfare gain to PCR	−27.9	−2.0

Note: See table 2 note.

lumber may experience either gains or losses depending upon the feedback effect, the results provide a dilemma for proponents of a restriction intended to maintain low lumber and regional housing prices. If an export ban results in a gain to regional lumber users (small feedback), there will be a substantial net welfare loss. On the other hand, if the regional resource misallocation cost is small, there is a loss to regional lumber users. Finally, the findings indicate that the net welfare effect for the Pacific Coast region is directly related to the effect on the log production industry and opposite to that experienced in the processing industry.

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Farm Size Evaluation in the El Paso Valley: A Survival/Success Approach

James W. Richardson and Gary D. Condra

Policy makers and agricultural economists in the United States have long been interested in the effects of size on farm survival and success. Most farm size studies to date have concentrated on economic efficiency and have failed to incorporate the effects of uncertainty, time, income taxes, financial considerations, and variation in year-to-year net cash flows on the survival/success of different size farms. A dynamic Monte-Carlo simulation-programming model was developed and used to analyze the projected survival/success of four alternative farm sizes for the El Paso Valley. For farms in the El Paso Valley, the projected chances of survival and success increase as farm size increases from 160 to 960 acres and/or beginning equity level increases from 25% to 100%.

Key words: farm size, farm survival, irrigation project, 160-acre limitation, simulation-programming.

Policy makers and agricultural economists in the United States have long been interested in the effects of size on farm survival and success. However, the current controversy about enforcement of the 160-acre limitation of the Reclamation Act of 1902 stimulated new efforts to identify and quantify these effects (e.g., Seckler and Young; Hall and LeVeen). This limitation would permit a farmer to own no more than 160 acres (320 acres with a spouse) of land irrigated from a Bureau of Reclamation project. Many arguments have been presented for and against this limitation on farm size. However, it is not the purpose of this paper to restate these arguments. Instead, it is to provide projections to the effects of size on farm survival and success.

The El Paso Valley was selected for study because it would be affected by enforcement of the 160-acre limitation more than any other area in Texas. Approximately 100% of the farmland in this valley is irrigated with Bureau of Reclamation water supplied from the Rio Grande Project. This area, located in the far western tip of Texas, receives less than 10 inches of rainfall annually. Thus irrigation is required for production of all crops, principally cotton, alfalfa, grain, pecans, and vegetables. Ground water is available as a secondary irrigation source.

Methodology

The need to incorporate uncertainty in studies of farm size has been pointed out by Heady (pp. 500–34), Olson, Raup (1969, 1978), and Madden and Partenheimer. Failure to account for uncertainty in farm size studies may cause the researcher to identify incorrectly the true long-run average cost curve and the most efficient farm size. For example, if uncertainty increases across farm size, the long-run average cost (LAC) curve will be shifted up and to the left, reducing the size of farm associated with minimum LAC.

Olson and Raup (1969, 1978) noted that most farm size studies have been static, i.e., for a single time period. These static studies did not account for year-to-year management problems, such as increasing costs of inputs, changing land values, changes in productivity, variation in crop prices and yields, and changing financial conditions. If these year-to-year factors increase the average total cost of production equally across all farm sizes, the same

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size would be optimal in both static and dynamic analyses. However, it seems unlikely that increased costs affect different size farms equally.

The effects on farm size of income taxes, financial considerations (debt refinancing, interest received on cash reserves, etc.), and variation in year-to-year net cash flows, generally have been ignored. Madden and Partenheimer, Raup (1969, 1978), and Olson suggested incorporating these factors because they influence the shape of the LAC curve. For example, existing income tax laws may provide added economies-of-size for farms large enough to qualify for special tax provisions.

Raup (1969) also wrote that the primary question farm size studies should address is: What size of farm is most likely to survive? Because the relationship between economic success (or viability) of farms in a dynamic, uncertain environment and economic efficiency in the static case has not been clearly established, farm management and policy decisions based solely on short-run economic efficiency could result in farm sizes that are economically unsuccessful in the long run.

One of the few farm size studies that has addressed the question of viability over a multiple-year planning period was done by Holland and Young. The economic viability of alternative farm sizes in the Columbia River Basin was evaluated using a deterministic model to simulate representative farms over a fifteen-year planning horizon. The simulation model computed annual after-tax net returns available for family living expenses. Costs and yields used in the model were based on representative management practices and current technology. Crop prices were held constant. Holland and Young evaluated the viability of various farm sizes at current and preproject land prices. In their study, (*a*) economic viability was used to address the question of optimal farm size, (*b*) a dynamic simulation technique was employed, (*c*) the traditional economic accounting approach was compared to an after-tax cash flow approach, and (*d*) the importance of land prices on the viability of a farm was analyzed. Still, this analysis did not account for the uncertainty of agricultural production and marketing. In addition, the study did not consider financial aspects of operating a farm, such as refinancing debts during periods of low income, accelerated debt repayment, the receipt of interest on cash reserves, and the effect of different beginning equity levels on a farm's survival.

Description of the Model

The model used for this study incorporates uncertainty in production and marketing activities over time. This was accomplished with a dynamic farm simulation-linear programming model. Several farm simulation models were available to analyze alternative farm sizes (e.g., Hardin, Held, Condra, and Hutton and Hinman). A modified version of the capital investment simulation model developed by Hardin was selected because it can simulate the annual production, marketing, financial, and income tax activities of a farm over a multiple-year planning horizon.

The programming-simulation model begins each year of the planning horizon by determining the farm's crop mix. A linear programming (LP) model is linked to the simulation model to permit the crop mix to change over time. The LP model maximizes the farm's expected net returns above variable costs, subject to constraints reflecting acreage allotments for pima cotton and rotation patterns.[1] This procedure has been used previously by Chien and Bradford and by Condra. Total variable production costs are calculated by multiplying variable costs of production per acre by planted acreages of the respective crops and summing over all crops. Crop prices and yields are drawn randomly from user-specified probability distributions. Total cash receipts are estimated as the product of harvested acreage, yield, and price summed over all crop enterprises.

The simulation model depreciates from machinery and depreciable items attached to the land (buildings, irrigation equipment, etc.), using either the straight-line or double-declining balance method. Farm machinery is replaced on a user-specified, replacement-purchase schedule with equipment loans ob-

[1] An adaptive expectations model was used to develop expected net returns per acre for the enterprises (Y_t^*). This approach has been shown by Fisher and Tanner to describe reasonably the process used by farmers to develop price and yield expectations. The basic model proposed by Nerlove is $Y^*_t = Y^*_{t-1} + \alpha(Y_{t-1} - Y^*_{t-1})$, where Y^*_{t-1} is the expected net return per acre in year $t-1$, Y_{t-1} is the actual net returns, and α is the coefficient of expectations. It is assumed that the coefficient of expectations equals 0.5. Expected net returns are a geometrically weighted average of past net returns. By using 0.5 for α, the variance of net returns is equivalent to a three-year moving average of net returns (Hillier and Lieberman).

tained as needed. Other production expenses, fixed costs, and family cash withdrawals are calculated each year based on the cost of these items in year 1 and their assumed annual inflation rates of 7% to 8%. Interest and principal payments for long-term and intermediate-term debts are based on the value of the original debt and a specified amoritization schedule. Income taxes for the farm operator are calculated using schedule Y for married individuals filing jointly. The income tax liability is adjusted for eligible investment tax credits and tax on capital gain.

Ending-year, after-tax, net cash income is calculated as total cash receipts less variable production costs, cash rents, fixed and other production expenses, principal and interest payments on outstanding debts, downpayments for machinery purchases, income taxes, and family cash withdrawals. Net farm income and other output variables are calculated at the end of each year. If after-tax net cash income is negative, the model meets the cash flow deficit by drawing on the farm's cash reserve or by refinancing its assets. A farm is considered to be insolvent if it is unable to meet annual net cash-flow deficits by borrowing against its equity in farmland and machinery. The creditworthiness of a farm is determined in each year of the ten-year planning horizon using the calculated ratio of equity to assets. If a farm has an equity ratio less than a user-specified minimum, it is declared insolvent

The ending-year value of owned farmland is calculated by inflating beginning-year land values by the annual inflation rate for farmland. Ending-year liabilities are calculated as beginning-year liabilities adjusted for principal payments, purchases of new farm machinery, and debt acquired from financing cash flow deficits. Ending-year cash reserves, liabilities, and assets are used as beginning-year values in the next year of the planning horizon. Thus the model is recursive.

Since the simulation model is essentially a cash flow simulator, validation is much simpler than if it were a behavorial model of farm growth. The model was validated by verifying each equation in the computer program for different deterministic runs. The LP model was validated independently and in conjunction with the simulator to insure overall validity. The average cropping patterns developed by the LP model were reviewed for realism by extension personnel and farm operators in the El Paso area. Further analysis showed that the LP model exhibited increased variability of cropping patterns; however, there is no significant difference in farm survival between the LP crop mix and a crop mix held constant at the levels observed for representative area farms.

Because the programming-simulation model replicates a multiple-year planning horizon a large number of times, it provides much information on both an annual and a summary basis. On an annual basis, data necessary to calculate experimental probability density functions (PDFs) is generated for each endogenous variable—cash receipts, production costs, income taxes paid, interest paid, depreciation, ending-year net after-tax cash flows, total assets, total liabilities, net worth, equity ratio, and cropping patterns. The expected performance of various size farms can be compared for each year of the planning horizon using the PDFs for after-tax net cash flows and the equity ratio.

The model also provides several summary statistics. One of the most useful is the cumulative probability distribution (CPD) showing the survival probability of a given farm. Survival is synonomous to solvency in this analysis. By comparing the CPD of survival for different farm sizes, one can determine which farm size has the best chance of surviving for a given number of years. Because each year-ending financial situation is the beginning financial situation for the next year, the probability of survival tends to decrease over the planning horizon.

A second summary statistic is the net present value CPD. The CPDs for net present value can be compared across sizes to determine which offers the highest probability of economic success. A farm was considered to be an economic success if it provided the owner a rate of return greater than or equal to the after-tax discount rate, i.e., a positive net present value. (An after-tax discount rate of 7.5% was used based on annual interest rates in the area of 10% and a marginal tax rate of 25%.)

Application of the Model

Four alternative farm sizes (160, 320, 640, and 960 acres) were evaluated for the El Paso Valley. Data on representative irrigated farms were developed from both primary and sec-

ondary sources. Information obtained from the Bureau of Reclamation and interviews with farmers was used to verify published values for production costs, machinery complements, average farmland values, and average crop prices and yields.

Sensitivity of these results was tested by analyzing three alternative beginning equity levels (25%, 50%, and 100%) and three land tenure situations (full ownership, combined ownership-lease, and full lease). These beginning equity levels were selected to represent farms in three different situations: (*a*) beginning farmers with a minimum amount of equity (25%), (*b*) commercial farmers using debt financing to expand existing operations (50%), and (*c*) farmers with full equity choosing not to expand via debt financing (100%). The minimum equity ratio for determining solvency was set at 20%.

A ten-year planning horizon was simulated recursively 100 times for each situation to generate probabilities of success and survival. In each iteration, the LP model was used to select acreage levels for crops annually over the ten-year planning horizon. A separate LP tableau was developed for each farm size based on the farm's available labor, cropland, operating capital, pima cotton allotment, and existing cropping patterns. Constraints on the cropping patterns reflected differences in equipment requirements and risk-bearing ability as determined by farm survey data. Because of high per acre production costs and price variability, noncontract vegetable (onions and lettuce) and alfalfa production was generally not observed on 160- and 320-acre farms. The primary difference in the LP tableaus from one farm size to the next was the mix of crops. All four farm sizes were allowed to grow cotton. Smaller farms (160- and 320-acres) were not allowed to grow noncontract vegetables or alfalfa. The larger farms (640- and 960-acres) could grow alfalfa, and the 960-acre farms could grow up to 48 acres of noncontract vegetables.

Constraining cropping patterns in this way narrows the question addressed by this study to some extent. It may be that significantly larger acreages of noncontract vegetables, pecans, and other high-value crops could be produced. However, this would involve substantial changes in marketing conditions and facilities in this area. Therefore, this study does not assess the possible effects of a large-scale shift to higher-value crops upon the economic survival and/or success of a given size farm. While this is a relevant question, it involves a change in market structure of sufficient magnitude to place it beyond the scope of this paper.

To incorporate production and marketing uncertainties, annual values for crop prices and yields and water allotments were drawn at random from empirical probability distributions. Deviations from trend over the 1960–77 period and mean crop prices and yields (trended at 7% and 1%, respectively) were used to develop these empirical probability distributions over the ten-year planning horizon. (This procedure was suggested by Luttrell and Gilbert.) Stochastic prices and yields were appropriately correlated, based on their historical correlation coefficients.[2] Stochastic water allotments were used in the LP model to reflect availability of water from the irrigation project and to determine required pumpage of irrigation water. Target prices for cotton and small grains were used when stochastic prices were less than target prices.

The average variable cost of production for each crop was developed from farmer interviews and budgets prepared by the Texas Agricultural Extension Service and the Department of Agricultural Economics at New Mexico State University.[3] Fixed costs for each farm size (i.e., property taxes, Bureau of Reclamation water charges, legal and accounting fees, and liability insurance) were developed from farm interviews. Family living expenses were treated as a fixed, non-tax deductible annual expense. While a constant family living expense may overstate cash withdrawals during periods of low cash flows, interviews indicated that farmers maintained about the same standard of living in recent years despite considerable variation in cash flows. An opportunity cost for owner-operator labor ($11,800 per year) and a standard management fee ($20 per acre) were used to de-

[2] Prices and yields were correlated by multiplying the square root of the correlation matrix for prices and yields by a vector of standard normal deviates. The product was transformed to a unit scale (0 to 1) by integrating the appropriate area under a standard normal distribution. These resulting values were mapped into the appropriate empirical probability distributions for crop prices and yields using a table look-up function. This procedure has since been described and used by King (pp. 207–39).

[3] The interview results indicated that there was more variation in per acre variable costs within a given farm size than across farm sizes. This is consistent with earlier farm size studies reviewed by Olson and by Madden and Partenheimer. Therefore, the average variable costs of production across farm sizes were used as the variable cost of production for all four farm sizes.

velop the family living expense values for the different size farms.

Representative farm machinery complements for the four farm sizes were based on engineering data and interviews with farmers. Machinery was valued at existing costs for new machinery. It was assumed that a farm would replace one-tenth of its farm machinery each year, maintaining its initial complement over time. The assumed per acre machinery investments in year 1 were $575, $636, $580, and $544 for the 160-, 320-, 640-, and 960-acre farms, respectively. The 320-acre farm had the highest per acre investment in machinery because it is just large enough to justify owning some equipment that a smaller farm would lease (e.g., a cotton picker) but not large enough to spread the investment to per acre levels observed for the 640-acre farm.

Farmland value was assumed to appreciate at 10% annually, while the value of capital improvements and new machinery was increased at 5% and 8% per year, respectively. Used equipment value was assumed to increase at 4% per year. Average variable production, harvest, and fixed costs were assumed to increase at 8% per year. Family living expense was assumed to increase at 7% per year to maintain the family's initial purchasing power. Crop prices and yields were assumed to increase at 7% and 1% per year, respectively, over the planning horizon.

Results

Average cropping patterns for the ten-year period are shown in table 1 for each farm size These plans were generated by the LP model Since variable production costs per acre were held constant across farm size for each crop, variations in proportional cropping patterns between farm sizes can be attributed to the following restrictions in the LP model: (*a*) alfalfa was not grown on the 160- and 320-acre farms because of machinery requirements and (*b*) noncontract vegetables were grown on only the 960-acre farm. While these assumptions are consistent with practices in the area and sound farm planning principles, it should be recognized that these cropping patterns are not normative in the traditional LP sense.

The results from this study, presented in the following tables, are arranged by farm size, beginning equity ratio, and tenure situation. Farm size refers to total acres farmed. Beginning equity ratio is designated by a Roman numeral, where I signifies 50% beginning equity and II signifies 100% beginning equity. Tenure situation is represented by letters: A signifies 320 acres of land cash-leased with the remainder owned; B signifies all owned land. For example, I-A represents a farmer with 50% beginning equity, 320 acres cash-leased, and the remainder of the land fully owned. With the 640-acre farm, the owned acreage is 320 acres and 320 acres are cash-leased.

The 25% beginning equity level and total cash lease situations were analyzed, but the results are not presented because neither situation provided a significant chance of survival. With only 25% beginning equity, the farms were over-leveraged. With straight cash-lease farms, appreciation in land value was not available to the operator to improve his credit capacity over time. Insolvencies in these situations generally occurred before the fifth year in the planning horizon because annual net cash flow deficits greatly exceeded the farm's capacity to refinance them.

The projected chance of survival (i.e., remaining solvent) over the next ten-year period

Table 1. Average Simulated Harvested Acreages for Crops on Representative 160-, 320-, 640-, and 960-Acre Farms, El Paso Valley, 1979–88

Farm Size	Upland Cotton	Pima Cotton	Alfalfa	Barley	Grain Sorghum	Red Chile	Fall Onions	Fall Lecttuce
	(Harvested Acres)[a]							
(Acres)								
160	52.7	56.5	0.0	12.2	15.4	7.2	0.0	0.0
320	105.4	113.1	0.0	24.4	30.7	14.4	0.0	0.0
640	198.1	181.2	57.6	49.4	60.9	28.8	0.0	0.0
960	288.3	272.4	216.0	2.4	2.7	43.2	32.0	7.0

Note: No significant trend was observed in the annual mean values over the ten-year planning horizon.
[a] To account for nontillable acres, the sum of harvested acres is equal to 90% of total acres.

Table 2. Projected Chance of Survival for Various Size Farms under Alternative Beginning Equity and Land-Ownership Situations, El Paso Valley, 1979–88

	Chance of Survival			
	I-A[a]	I-B[b]	II-A[c]	II-B[d]
Farm size (Acres)	(%)			
160		1		100
320		14		100
640	5	88	100	100
960	90	100	100	100

Note: Survival is defined as having an equity ratio greater than 20%.

[a] 50% beginning equity, 320 acres cash-leased, remainder owned.
[b] 50% beginning equity, all owned land.
[c] 100% beginning equity, 320 acres cash-leased, remainder owned.
[d] 100% beginning equity, all owned land.

is shown in table 2 for the selected sizes of farms under alternative situations in the El Paso Valley. The 160- and 320-acre farms had a 100% chance of survival under situation II-B. However, in the 50% beginning equity situation (I-B), the chance of survival was projected to be very low. The 640-acre farm had a relatively high chance of survival under all situations except the 50% beginning equity with combined ownership and cash land lease (I-A). The 960-acre farm had a relatively high chance of survival under all four situations.

For a given beginning equity ratio and ownership situation, the chance of survival generally increased with farm size. The chance of survival also increased directly with the beginning equity ratio for a given farm size and ownership situation. This is because farms with a high beginning equity ratio have greater capacity to refinance net cash flow deficits during bad years. In addition, larger farms benefited more from appreciation in farmland values than smaller farms. This provided a relatively high proportion of the net worth increase over the ten-year period.

The projected chance of survival for a given number of years is shown in table 3. These results show that the 160-acre farm with 50% beginning equity (I-B) had only an 18% probability of surviving for five years. The 320-acre farm (I-B) had a much higher probability of surviving for five years, but only a 27% greater probability of surviving for seven years. The 640-acre farm combining ownership with lease of land and 50% beginning equity (I-A) had a

Table 3. The Projected Chance of Survival for Various Size Farms under Alternative Beginning Equity and Land-Ownership Situations, El Paso Valley, 1979–88

	Chance of Survival					
	Situation I-A[a]		Situation I-B[b]			
	640 Acres	960 Acres	160 Acres	320 Acres	640 Acres	960 Acres
Years	(%)					
3	59	100	100	100	100	100
4	42	95	57	93	100	100
5	25	92	18	71	99	100
6	17	92	17	53	98	100
7	14	92	5	32	96	100
8	9	91	2	20	94	100
9	6	90	1	17	90	100
10	5	90	1	14	88	100

Note: Survival is defined as having an equity ratio greater than 20%.
[a] 50% beginning equity, 320 acres cash-leased, remainder owned.
[b] 50% beginning equity, all owned land.

survival pattern very similar to the 160-acre farm (I-B); but, when full ownership of land was considered (640-acres, I-B), the chances of survival for a given number of years remained high. In fact, the 640-acre farm (I-B) which survived for six years had only about a 10% probability of failure in the last four years of the period.

Table 4 shows the chance of success (i.e., a net present value greater than or equal to zero) for the selected farm sizes and situations. No significant chance of success was projected for

Table 4. The Projected Chance of Success for Various Size Farms under Alternative Beginning Equity and Land Ownership Situations, El Paso Valley, 1979–88

	Chance of Success			
	I-A[a]	I-B[b]	II-A[c]	II-B[d]
Farm size (acres)	(%)			
160		0		0
320		0		6
640	0	0	11	80
960	14	44	94	100

Note: Success is defined as having a new present value greater than or equal to zero.
[a] 50% beginning equity, 320 acres cash-leased, remainder owned.
[b] 50% beginning equity, all owned land.
[c] 100% beginning equity, 320 acres cash-leased, remainder owned.
[d] 100% beginning equity, all owned land.

the 160- and 320-acre farms under any situation. The 640-acre farm had a significant chance of success in only one case, 100% beginning equity and ownership of all the farmland (II-B). The 960-acre farm had a high chance of success under the 100% equity situation; however, the chance of success was less than 50% for both situations with lower beginning equities (I-A and I-B). As in the case of survival, the chance of success increased directly with farm size and beginning equity ratio.

These results seem to support the hypothesis that larger farms in the El Paso Valley are more economically viable. However, the increased chance of survival and success does not depend on the operational characteristics of larger versus smaller farms. Instead, the larger farms had (*a*) lower management cost per acre and (*b*) a larger land asset base to appreciate over time.

The relationship between tenure situations (full ownership versus owner-cash lease) and the chance of survival and success is less consistent than that with farm size and beginning equity. The comparison of tenure situations can be made (*a*) between the same size farms with different tenure situations, or (*b*) between farms with the same owned acreage. The first comparison for a 640-acre farm with 50% beginning equity (640 acres, I-B versus 640 acres I-A) indicates that going from full ownership to an owner-cash lease situation decreased the chance of survival from 88% to 5% (table 2). However, the second comparison for a farm with 640 acres owned and a beginning equity of 50% (640 acres, I-B versus 960 acres, I-A) indicated that the owner-cash lease tenure situation increased the chance of survival from 88% to 90%. This inconsistency for tenure situations also exists for chances of success (table 4). Therefore, it can be said only that for a given size of farm, the chances of survival and success are higher if all the land is owned. Analysis revealed that land value appreciation played a major role in providing increased net worth which, in turn strongly increased the chance of survival. The cash lessee received no benefit from increased land values, whereas the land owner received a benefit in increased borrowing capacity.

Conclusions and Implications

First, there is a well-defined, direct relationship between farm size and/or beginning equity level and the chances of survival and success for farms in the El Paso Valley. This relationship is consistent throughout the results, covering a range of farm sizes from 160 acres to 960 acres. The results also suggest that this relationship probably extends beyond the 960-acre farm size.

The second major conclusion is that a straight cash-lease farm operation has little chance of survival and success. Cash-lease as a traditional growth strategy for young farmers does not appear to hold great promise in the El Paso Valley. The results show that a farmer needs to have at least 50% beginning equity in 640 acres of owned land before cash lease of 320 acres can be expected to improve the chance of survival and success.

The third conclusion is that the minimum size and beginning equity situation that will provide a reasonable chance of survival and success in the El Paso Valley for the next ten years is 100% beginning equity in 640 acres of owned farmland. "Reasonable chance" in this case is a 50–50 or greater chance of achieving both objectives, survival and success. This is not to say that a smaller farm and/or a lower beginning equity level cannot survive or succeed. However, a farm with less than the minimum situation (640 acres owned with 100% beginning equity) likely will not survive the next ten years. If it survives, its financial situation probably will deteriorate over that period. In this setting, the farmer will not replace worn-out equipment or practice conservation practices requiring capital investment. He will simple deplete his equity. This farm likely will not generate the required capital for growth. In the context of this study, growth to a larger size or a sizable beginning equity level is the only way to achieve a reasonable chance of success.

The capital requirement for a fully owned 640-acre farm, with 100% equity was assumed to be $1,651,000. Given that this is the net worth the farmer must start with to achieve a reasonable chance of survival and success, it is hard to see how young people will be able to enter farming in the El Paso Valley.

Much of the current interest in minimum viable farm size comes from the 160-acre limitation controversy. These results suggest that the minimum viable size for a commercial farm in the El Paso Valley is 640 acres or larger. If this is true, limiting acreage to less than 640 acres probably would not accomplish the policy objective of encouraging smaller,

family-owned farms. Instead, it would restrict farms to sizes which have little chance of survival and economic success, unless major changes occur in the Valley's production patterns.

Hall and LeVeen have argued that restricting the size of farms to a smaller than an economically viable size would result in reduced land values which, in turn, would restore economically viable agricultural production at a smaller size. Maybe such a process would occur in the El Paso Valley. However, it seems more likely that the long-run effects would be to increase the cost of holding land for suburban development and thus hasten the conversion of land to nonagricultural uses.

The major policy implication of this study is that enforcement of the existing 160-acre limitation in the El Paso Valley would restrict farms to a nonviable size. However, enforcement of the acreage limitation currently being considered by Congress, 960 acres per farming unit, would not be a barrier to the development of economically viable size farms in the Valley. While the results of this study may not be readily transferrable to other Bureau of Reclamation projects, the methodology can be used to determine the minimum viable farm size for other irrigation districts in the West.

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Return Flow Control Policy and Income Distribution among Irrigators

Daniel J. Dudek and Gerald L. Horner

Income distributional impacts and irrigation return flows resulting from the implementation of alternative water quality policies were projected for the Western San Joaquin Subbasin from a recursive simulation of an integrated physical-economic analytical system. The imposition of a water management policy to increase irrigation efficiency resulted in an improved income distribution with a slight decline in average firm income. Salt load and concentrations were reduced by 80%. A policy of increased surface water costs worsened income distribution and decreased average firm income by 34%. Total salt load decreased by 35%, but the concentration in return flows was only slightly decreased.

Key words: income distribution, irrigation return flows, salinity, water management, water pricing.

While economics is concerned with economic well-being as described in terms of both efficiency and equity, public and academic economists seem preoccupied with the efficiency criterion in policy analysis, particularly with respect to natural resources. Explicit attention to equity or the distributional impacts of policy have been subsumed in the estimation of aggregate benefits and costs irrespective of distribution. While it is true that distributional analysis is hampered by a lack of precision in the specification of equity criteria, we argue that such analysis should occupy a more critical role in policy evaluation. In particular, distributional analysis, whether of income or wealth, is a comprehensive socioeconomic evaluation of public policy that delineates who benefits and who pays. Such analysis has implications as well for the need for and design of compensating programs such as cost sharing. Distributional analysis also may indicate the existence of synergistic and/or antagonistic effects between proposed and operating policies and programs. Recognizing the crucial policy role such analysis may occupy, it is our intent to demonstrate its significance in an empirical context. Thus, this paper reports the income distributional impacts within a San Joaquin Valley irrigation district from the implementation of two alternative water quality policies to manage irrigation return flows.

Several empirical approaches can be applied in assessing the distributional impacts of natural resource policy. The basic underlying contention is that the institutional environment defining property rights in resources and public policy directed toward those resources affects the distribution of income. Distributional effects, whether resulting from the direct application of economic incentives in the form of taxes or subsidies or resulting indirectly from restrictions on resource supply or use, may be represented by a single index number such as the Gini coefficient (Hansen and Schwartz), as net impacts upon classified groups (Collins), or as an estimated function for the Lorenz curve itself. Each of these approaches has merit. In this analysis, both the Gini coefficient and gross impact by income group are used to represent the income distribution resulting from each alternative policy. Despite the fact that a unique correspondence between Gini coefficients and income

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distributions does not exist, they are useful comparative summary measures of distributional impacts.

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) outline broad water quality goals for the nation and establish mandates for each state to control point and nonpoint sources of pollution from all man-made activities. Pollution from irrigation return flows was originally classified as a point source and thus subject to the National Pollution Disposal Elimination System Permit Program. However, in 1977 the Clean Water Act (PL 95-217) reclassified irrigation return flows as a nonpoint source and, as such, subject to the procedures outlined in Section 208 of PL 92-500. Section 208 requires that nonpoint sources of pollution be identified and that procedures for control be specified as "Best Management Practices" (BMP). The specification of BMPs and a schedule for implementation are to be a part of the Areawide Waste Treatment Management Plans which must be submitted to the Environmental Protection Agency (EPA). Section 303 of PL 92-500 requires that the state adopt a continuing planning process that is consistent with all provisions of the Act. This process is designed to insure that the initial plan formulated under Section 208 remains effective under changing economic and environmental conditions. In addition to its planning responsibility, each state must prepare an estimate of (*a*) the environmental impact, (*b*) the economic and social costs necessary to achieve the objectives of the act, and (*c*) the economic and social benefits.

Determining the distribution of benefits and costs by socioeconomic or geographic group resulting from specific BMPs is an important criterion in evaluating a Section 208 plan. Two policies that could be specified as BMPs to reduce irrigation return flows in the San Joaquin Valley were evaluated for changes in water quality and income distribution. These policies are (*a*) to increase the price of irrigation water supplied from surface developments and (*b*) to alter water management practices so as to attain a targeted 30% efficiency increase. These policies were evaluated by simulating farmers' decisions and estimating irrigation return flows using data from the Cen-melons are the principal crops grown on the 145,000 irrigated acres comprising the District. Farmers in the district used an average of 3.82 acre-feet of irrigation water per acre in 1976. Water costs to the farmer included a fixed assessment of $2.15 per irrigated acre and a variable charge of $2.50 per acre-foot of water delivered. Approximately 15% of the District's water supply is groundwater. Surface and subsurface irrigation return flows are collected and disposed in the San Joaquin River.

Methodology

The alternative water quality policies were evaluated with the integrated land and water resource analytical system presented in figure 1. Specific policy impacts were estimated in the water quality subsystem. Its principal analytical components consist of two location-specific models sequentially linked to simulate spatial and temporal changes in agricultural production and water quality. Each model contains 126 subregions encompassing 2.78 million acres in the San Joaquin Subbasin. These subregions were defined such that the soils comprising each are homogenous with respect to yield characteristics, response to fertilizer, management, and land treatment measures. These subregions range in size from 1,498 to 78,711 acres, with a mean size of 22,081 acres.

Production Model

The linear programming model derives optimal cropping patterns, water, and fertilizer use for each subregion or cell. The specification of alternative cultural practices for each cell allows the estimation of spatial and temporal changes in agricultural production and return flows as a result of changes in policies. The model is segmented into regional activities and cell-specific (subregional) activities. Regional activities include crop production and commodity marketing. These activities are aggregate since sufficient differences do not exist in either market prices or production costs (other than irrigation and land costs) among the cells of the study area.

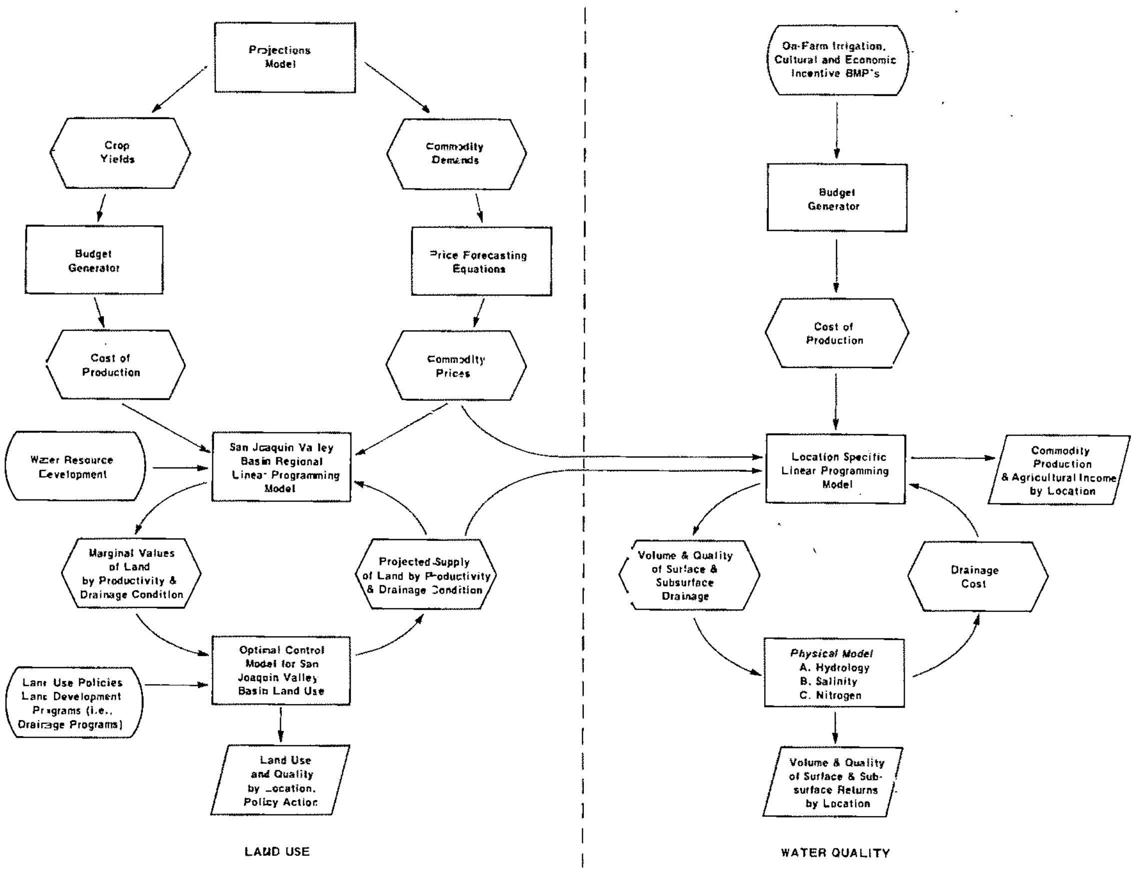

Figure 1. Integrated land use, water resource and water quality analytical system

use produced under alternative land use and water quality policies. Crop rotations for each individual cell are specified according to actual cropping patterns. Drainage costs are reflected in the objective function as determined by the physical model. Cropping patterns can be changed as a result of price changes or they could be mandated as land use or water quality policies. Land conversions from idle to perennial or nonperennial crops can occur if sufficient water supplies are available.

Crop evapotranspiration (ET) is specified in order to isolate water requirements from water application efficiencies. Research is currently being conducted to determine the effects of reducing ET requirements by stressing plants during noncritical stages of growth. Alternative water application technologies available within the production model include furrow and sprinkler systems that are both scheduled and nonscheduled. Water application efficiency and surface runoff are estimated for each technique to account for the total amount of water diverted for irrigation. The possibility of subsidizing more efficient water application techniques has been considered as a BMP to reduce irrigation return flows. Sources of water include surface diversions and wells pumping primarily from the confined aquifer. Levying a pump tax or increasing surface water prices to reduce water use is possible. Surface runoff or tailwater can either be captured and reused or disposed of in surface watercourses. Effluent charges on surface disposal or the subsidization of tailwater recycle systems could be implemented to reduce return flows. Crop nitrogen requirements and alternative application techniques are included as well. Solutions to the LP model are constrained by water supply, processing capacity, crop rotation requirements, and the amount of irrigable land.

Physical Model

Results from the LP model serve as data inputs to the other location-specific model which

describes the response of the physical environment. This physical model is partitioned into two interdependent submodels that analyze the hydrology and salinity balances of the soil profile on the same spatial and temporal basis as the LP. These submodels estimate the effects of irrigation water and fertilizer use on water table depths and the quantity and quality of irrigation return flows.

The hydrology model generates predictions of the rates of deep percolation through the soil, subsurface drainage, rates of groundwater flow among cells, and the movement of the water table in the unconfined aquifer. The soil type, depth of water table, ground surface elevation, and the depth of the impermeable layer are assumed homogenous throughout each cell. In each cell, the annual rate of deep percolation in time t is computed as a function of water inputs and outputs at the surface. Therefore,

$$(1) \qquad DP_{kt} = g_k(I_{kt}, R_{kt}, ET_{kt}, RO_{kt}),$$

where DP_{kt} is deep percolation; I_{kt}, irrigation applications; R_{kt}, rainfall; ET_{kt}, evapotranspiration; and RO_{kt}, surface runoff, all in cell k.

In those cells in which the water table is within 5 feet of the surface, a drainage system is assumed to be installed only if it is determined in the LP model as economically feasible. In a cell where a drainage system has been installed, the rate of drainage is computed from the rate of deep percolation and the movement of the water table. The change in the water table depth between time periods is defined by

$$(2) \qquad H_{kt+1} = H_{kt} + s_k(DP_{kt}, P_{kt}, \sum_{j}^{n} F_{jkt}),$$

where H_{kt} is water table depth in cell k, P_{kt} is water pumped from cell k, and F_{jkt} is groundwater movement from (to) cell j to (from) cell k.

The groundwater flow between cells is calculated according to Darcy's Law, in which spatial and temporal averages of water table depths are used to arrive at an average hydraulic gradient between cells. A spatial average is used as a coefficient of permeability of the cells. The area through which the flow moves is equal to the product of the length of the common boundary and the time-averaged depth of the saturated zones. One equation of the form of equation (2) is written for each cell resulting in n equations for n cells in n unknowns, i.e., the final water table depth for each cell. This system of equations is then solved through Gaussian elimination.

One of the quality changes taking place in the soil moisture is increased total dissolved solids (TDS) concentrations due to evapotranspiration and chemical processes in the soil. Salt pickup in an irrigated soil is primarily a function of the chemical composition of the soil and applied water and the leaching fraction (Rhoades et al.). Analysis of the total annual salt load carried by subsurface drains in the area implied that the total annual salt load per acre in tile drains is related to the total volume of water carried by the drain. It was therefore assumed that the annual rate of salt pickup for each cell can be approximated by the expression,

$$(3) \qquad SL_{kt+1} = SL_{kt} + c_k(DP_{kt}, Q_{kt}),$$

where SL_{kt} is amount of salt in the leaching water, and Q_{kt} is quality of irrigation water applied. These functional relationships were estimated for various qualities of irrigation water using a model developed at the U.S. Salinity Laboratory at Riverside, California (Rhoades et al.).

A weighted average of the salinity concentration of groundwater within a cell is used to estimate the quality of water pumped from drainage sumps and wells within the cell and the quality of water moving outward across the boundaries of the cell. This assumes, in effect, that all strata contribute proportionate shares to flows from the aquifer. Although wells generally will draw water from some strata more than others, it would have been impractical either to differentiate between the various strata in every cell or to determine the characteristics of every well in the study area. In addition, the gravel-pack wells used in the area result in some mixing between strata.

The quality of surface runoff was assumed to be the same as the quality of applied water. This approximation was supported by data observed for various locations in the valley. The salinity submodel estimates the quality of deep percolation as it moves through the unsaturated zone. Water entering subsurface drains was assumed to have the same quality as that of percolation water, at a depth of 6 feet.

Solutions from the models are estimated annually to simulate adjustments derived from policy changes affecting irrigated agricultural practices. Thus, the analytical system is sufficiently comprehensive to evaluate alterna-

tive resource use policies in terms of their economic and environmental impacts. It is structured so as to provide a spatial and temporal dimension for all parameters. Clearly the distribution of resource problems through time and space is a significant determinant of resource policy. In addition, the linkage of micro and macro characterizations of resource use among the component models of the analytical system allows broader implications to be drawn about the nature of demands for land and water resources under diverse sets of policy options. The system is discussed more completely in Horner and Dudek.

Procedure

Cropping patterns, returns to land and management, and the quantity and quality of irrigation return flows in CCID were estimated by the analytical system by subregion for the period 1974–85. Because the integrated analytical system encompasses a substantially greater area than that comprising the CCID, it was necessary to establish a correspondence between subregions and operating units of the irrigation district. CCID is wholly contained within sixteen subregions. The sizes of farm firms in each subregion within CCID were determined from district water billing records. Before tax, farm-related, net returns to land and management for the period of analysis were converted to an average annual present value basis and employed as an estimate of income. These average annual returns were then adjusted to reflect economies of size of operation (Moore, Moore and Hedges). Finally, firms were grouped by income class and Gini ratios were determined for a base situation and two policy alternatives.

Policy Alternatives

The two policies evaluated to reduce irrigation return flows are (*a*) implementing a $22 per acre-foot price for surface water and (*b*) requiring water management practices and methods that result in an increase in on-farm water use efficiency of 30%. Increasing the price of water to account for the negative externalities associated with irrigation return flows is an indirect approach that is necessitated by the nonpoint source nature of the pollution problem. If return flows were a point source problem, an effluent charge would be a direct approach to the internalization of these externalities. Water prices in the West vary because they are established by water agencies and districts to allocate diversion and distribution costs to water users. This pricing structure results in greater water diversions, production, incomes, and return flows than would occur under higher water prices (Howe and Orr, California Department of Water Resources). Increasing the price of irrigation water is as effective as an effluent charge system in reducing environmental damage if diversions are proportional to the pollution caused by return flow disposal. Howe and Orr contend that sufficient correlation exists.

The water management policy assumes continuation of the existing water price structure and imposition of mandatory water conservation practices within the area. Water conservation practices that could be mandated include structural measures for the improvement of water conveyance and delivery systems as well as improved on-farm water management. Distribution system efficiency could be improved through the construction of less permeable canal and lateral linings and the use of flow measurement systems. Improved on-farm water management includes the use of more efficient water application techniques and systems, irrigation scheduling, tailwater recycle systems, decreased furrow slopes and lengths of run, and minimum leaching fractions to decrease deep percolation. It is assumed in this analysis that suitable combinations of these practices, if implemented, would produce an increase in water use efficiency of 30%. Because these practices could be subsidized under the Rural Clean Water Program of the Clean Water Act of 1977, their implementation would result in little or no additional cost to farmers but would represent transfers from the general fund, which should be recognized.

Results

The average returns to land and management per farm firm and the amount and quality of irrigation return flows for the base and two policies are presented in table 1. Average returns decrease slightly as a result of imposing the water management policy. This is because of a slight shift in the location of processing tomatoes outside district boundaries to other subregions within the subbasin. Total re-

Table 1. Average Returns to Land and Management, Amount and Quality of Irrigation Return Flows by Policy

		Policy	
	Base	Water Management Policy	Increased Surface Water Prices
Average returns to land and management per farm firm	$43,768	$42,522	$28,783
Irrigation return flows (AF)	164,000	151,000	103,000
Salt load (tons)	329,000	58,000	213,000
Salt concentration (PPM)	1,836	356	1,897

gional acreage of tomatoes is constrained by the capacity of local processing facilities. Some areas outside CCID were constrained by water supply. Thus, when the water management policy increased the effective supply of water, tomato acreage was increased in these previously water-short areas. More significantly, average returns were decreased by 34% under the policy of increasing surface water prices.

The environmental degradation potential of irrigation return flows within CCID was reduced under either policy option. In the case of the water management policy, total water use was reduced because of improvement in on-farm water use efficiency. Since surface water supply sources for CCID are the least cost, groundwater pumping in the district is reduced. These pumping reductions combined with the naturally higher quality of surface water result in increases in the average quality of applied irrigation water, decreases in the amount of water lost to deep percolation, and improvement in the quality of tailwater and subsurface drainage.

Using the water-pricing policy, the total volume of irrigation return flows is even more dramatically reduced. However, this 37% reduction in return flows belies the fact that salt concentration is approximately the same as in the base period. Because the concentation of salt in return flows is roughly equivalent in the base and water pricing scenarios, total salt load under higher water prices is reduced in proportion to the reduction in return flow volume. Average return flow quality under the improved water management policy, in contrast, is sufficiently good for recycling in agricultural use or disposal without environmental degradation. This substantial reduction in salt load is a direct result of the higher average quality of applied irrigation water and the reduction in volume of both surface and subsurface return flows under the water management option.

Results of the Distributional Analysis

The impact of the two alternative policies on income distribution will be described according to their overall effects, by income class and by income quartile. Table 2 presents basic income distributions for the base, water management policy, and water-pricing option. These distributional impacts are quantified in terms of income and firm number effects. Since the objective function of the location-specific linear programming model maximizes net returns to land and management, no attempt has been made to estimate the dynamic impact of the policy alternatives upon the prices of these inputs. Clearly, changes in water pricing and/or mandated management practices may change expected future returns to these factors of production and thus the intertemporal wealth position of farm firms.

Increasing water use efficiency, when compared against the base condition, has the overall impact of increasing the percentage of income concentrated in the lower end of the distribution of income classes and decreasing that in the upper portion. The largest changes in distribution by income class were a 4% loss in total income share in the $50,001–$60,000 range and a 5% gain by the $70,001–$80,000 class when compared against the base distribution (table 2).[1] Other changes were of a smaller order of magnitude and distributed throughout the range of classes.

[1] These percentage impacts are calculated from table 2 by first determining the percentage of income or firms within an income range in the base period and then subtracting the corresponding percentage outcome from the policy alternative under consideration.

Table 2. Income Distribution under Alternative Water Quality Policies

	Base			Water Management Policy			Increased Surface Water Price		
	Number of	Cumulative Percentage of		Number of	Cumulative Percentage of		Number of	Cumulative Percentage of	
Income Range ($)	Firms	Firms	Income	Firms	Firms	Income	Firms	Firms	Income
Under 10,000	184	25	3	163	22	3	268	37	5
10,001– 20,000	63	34	6	84	34	7	272	74	26
20,001– 30,000	269	71	26	269	71	27	33	79	30
30,001– 40,000	41	77	30	37	76	31	31	83	35
40,001– 50,000	16	79	33	27	80	35	36	88	43
50,001– 60,000	33	84	39	12	82	37	24	92	49
60,001– 70,000	25	87	44	31	86	43	5	92	51
70,001– 80,000	5	88	45	25	89	49	4	93	52
80,001–100,000	32	92	54	23	93	56	13	95	58
100,001–200,000	38	97	73	37	98	73	25	98	73
Over 200,000	19	100	100	17	100	100	14	100	100
Gini Coefficient		0.61			0.59			0.65	

In examining the impact upon firm numbers as distributed by income class, it can be seen that the general trend is an evening out with numbers shifting toward the middle from each end of the distribution. The greatest specific changes in firm numbers were 3% losses and gains in the $0–$10,000 and $10,001–$20,000 classes, respectively. The lowest income firms have benefited from the management policy. In addition, there was a 3% decrease in firm numbers in the $50,001–$60,000 classification. The Gini coefficient under the water management option relative to the no-policy option declined from 0.61 to 0.59. Thus, according to this measure, income distribution was improved.

The distributions of income and firms by income class under the water management policy option can also be summarized by aggregating the eleven ranges of income into quartiles. Each of the quartiles would then correspond to the following income spreads: I, $0–$30,000; II, $30,001–$60,000; III, $60,001–$100,000. and IV, greater than $100,000. The changes in income and firm number distributions resulting from the implementation of a policy to improve irrigation efficiency are summarized in table 3. The third quartile, ($60,001–$100,000), is most changed by imposition of the management policy. Firms in the upper end of the second quartile have benefited enough from the reduction in their total water bill through improved irrigation efficiency that they moved into the third quartile. Due to cropping pattern changes in the solution to the programming model with the management policy imposed, firms in the fourth quartile experience income decreases and 1% of them move down into the third quartile.

The overall impact of pricing water at $22 per acre-foot on the relative frequency of income by class is an almost exact displacement of the distribution one class downward relative to the base condition. Firm numbers in all but three classes have been reduced and the greatest concentration of firms occurs in the two lowest income classes. Using this policy, the Gini coefficient has increased to 0.65, thus the income distribution is worsened compared to the base. The specific impacts by class are much greater than those which result under the management policy. Income in the $10,001–$20,000 range increased by 18%, since firm numbers for this class also rose by 18% (table 2). Also heavily affected was the $20,001–$30,000 class, which lost 16% of income and 22% of the firms. Firm numbers in the $0–$10,000 class rose by 12%, bearing out the conclusion that the heaviest impacts accrued at the lower end of the income distribu-

Table 3. Net Changes in Relative Frequency by Quartile as a Result of the Water Management Policy

Quartile	Income Change	Firm Number Change
I	+0.01	0.00
II	−0.03	−0.01
III	+0.04	+0.02
IV	−0.02	−0.01

tion. The increased public revenues generated by this water-pricing policy are presumed to be returned to the general treasury. To the extent, then, that firms in different income classes share differently in the benefits of public programs, the income distributional impacts that have been estimated would be altered.

Examining the impacts by quartile of the water-pricing policy further emphasizes this result (table 4). The only quartile to display relative improvement under this policy option is II, but this is the result of firms in the lower end of the third quartile having income reductions of sufficient magnitude to displace them into the upper end of the second quartile. As has been indicated previously, the heaviest impact on firm numbers is in the first quartile.

In comparing the impacts of the alternative policies to control irrigation return flows, it is important to examine the cumulative distributions presented in table 2. In the base condition, 79% of the firms had 33% of the income, with an average per firm income of $18,275. Under the water management option, 80% of the firms occupied the range $0–$50,000 and had 35% of the income, which averaged $18,603 per firm. However, under the water-pricing policy, 79% of the firms were concentrated in the $0–$30,000 income range, and they shared only 30% of total income. The average per firm income under this policy declined to $10,925.

Conclusions

As a final comparison of the relative impacts of the policies, it is useful to consider the more detailed description of quartile data presented in table 5. It shows firm numbers, the average percentage of total income share per firm, and the average per firm income by quartile and policy. While the average percentage of income share per firm in the first quartile shows little change with either policy, the number of firms and average per firm income do change drastically under the water-pricing option. Firm numbers rise and average per firm income drops. Quartiles II and III are again quite similar for the base and management alternatives. However, water pricing produces a higher average percentage of income share per firm. This is the result of the displacement effect discussed earlier in this section, i.e., firms shifting down into the next lower income quartile. In the highest income quartile, average per firm income drops across policies, with the lowest level occuring under water pricing. In conclusion, then, the policy of water management to improve water use efficiency in order to control irrigation return flows beneficially affects the income distribution among firms in the study area and would thus be favored under the equity criteria employed in this paper.

The objective of this study focused on assessing the distributional impact of two alternative return flow policies on irrigators, representing one sector of the economy. This study does not address the larger question of economy-wide efficiency and equity, which may differ between the two policies. The pricing policy implies the flow of revenue from

Table 4. Net Changes in Relative Frequency by Quartile As a Result of the Water-Pricing Policy

Quartile	Income Change	Firm Number Change
I	+0.04	+0.08
II	+0.06	0.00
III	−0.06	−0.05
IV	−0.04	−0.03

Table 5. Distributional Impacts by Quartile by Policy Alternative

	Base			Water Management Policy			Water Pricing Policy		
Quartile	Firm Numbers	Average Income Share per Firm (%)	Average per Firm Income	Firm Numbers	Average Income Share per Firm (%)	Average per Firm Income	Firm Numbers	Average Income Share per Firm (%)	Average per Firm Income
I	516	0.050	15,866	516	0.052	16,031	573	0.052	10,851
II	90	0.144	45,694	76	0.132	40,694	91	0.209	43,613
III	62	0.242	76,791	79	0.241	74,297	22	0.409	85,349
IV	57	0.807	256,076	54	0.815	251,252	39	1.077	224,745

irrigators to the general fund and other sectors of the economy. Such revenues could even be used to provide lump sum payments to irrigators. The water management policy through a subsidy program implies a transfer of funds to the irrigators from the general fund and other sectors.

The research presented in this paper is intended to be illustrative of the type of information necessary for the design and evaluation of policies and programs for the control of nonpoint sources of pollution. The approval of Section 208 plans and their related BMPs will depend upon several evaluation criteria. The degree to which an environmental strategy can improve the overall quality of resources is the ultimate criteria. However, Bower et al. characterize the distribution of benefits and costs as the most important physical and economic effect of pollution control. This paper has demonstrated how irrigated farm firms in the Central California Irrigation District would either benefit or bear the costs of return flow control under alternative policies.

Our findings also demonstrate the flexibility of the model in analyzing two quite diverse policy alternatives: improved water use management and increased water prices. This analysis has included the ability to incorporate complex environmental effects, as well. Although the policies selected as illustrative alternatives are obviously not the only choices, their analysis demonstrates that environmental, efficiency, and equity considerations can be comprehensively evaluated in a systematic framework.

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Evaluating the Food and Agriculture Act of 1977 with Firm Quadratic Risk Programming

Wesley N. Musser and Kostas G. Stamoulis

Federal agricultural commodity programs generally have been assumed to reduce the income risk for farm firms, but limited empirical research exists on this proposition. This paper presents a study of the impact of the Food and Agriculture Act of 1977 on income risk for a representative farm in Georgia. The model is used to derive an E-V frontier for a firm not participating in the program and for the same firm that is participating in the program. Results indicate that participation dominates nonparticipation except for higher level of expected net income.

Key words: farm management, government commodity programs, quadratic programming, risk.

Farm income stability historically has been a justification for commercial agricultural policy in the United States (Schultz). Under earlier program forms of price supports above market equilibrium levels and maintenance of large Commodity Credit Corporation stocks, the risk arising from income instability was mitigated in conjunction with increasing farm income (Hathaway). With the advent of program forms that separated income support from price supports, reemergence of the income stability problem became a possibility. The increasing importance of agricultural exports, and especially their fluctuations, caused this stability problem to become a reality in the 1970s (Robinson, Schuh). During this same period, a new public commodity program form also evolved for wheat, feed grains, and cotton. The most recent general legislation related to this program form is the Food and Agriculture Act of 1977.

The effectiveness of the current farm program, authorized under the Food and Agriculture Act of 1977, in reducing income instability at the farm level has been given limited empirical consideration. Recent exceptions include Kramer and Pope, who concluded that participation is optimal for risk-averse California producers, and Persaud and Mapp, who found that selected program features can reduce risk in an Oklahoma farm situation. Scott and Baker reached similar conclusions in their earlier study of risk-returns trade-off in an Illinois farm situation, which included government programs under a previous act. The limited empirical analysis is particularly serious since policy analysts disagree on the impact of the Act on risk at the farm level. In the recent U.S. Department of Agriculture (USDA) report on structural issues, Penn, Harrington, and Johnson et al. all asserted (or assumed) that commodity programs reduce risk of farmers. In an earlier policy analysis of the 1977 Act, Spitze concluded that the 1977 Act would contribute to stability of farm income. However, Gardner questioned the effectiveness of the Act in reducing income variability because of its market orientation.

The purpose of this paper is to present an empirical study of incentives for a representative farm firm in South Central Georgia to participate in the 1977 Act. A standard quadratic programming model of a farm firm is used for an expected income-variance (E-V)

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analysis of the nonparticipation situation. This basic model is then modified to include important policy provisions of the Act, including loan rate, deficiency payments, set-aside, voluntary diversion, and disaster payments, for an E-V analysis of the participation situation. A major methodological problem in the participation model is the estimation of a variance-covariance matrix of incomes for commodities covered under the Act; the approach to this problem used here is to synthesize data to estimate these parameters. The results of the study provide some implications for the risk reduction possibilities of participation in a voluntary commodity program.

Methodological Background

The standard presumption that an important goal of agricultural commodity programs is increased stability of farm income implies the assumption that farmers are risk-averse. The theoretical foundation of this proposition is that farmers maximize expected utility. Assuming that the utility function is quadratic or that net incomes are normally distributed, the optimum under an expected utility objective can be expressed as a trade-off between risks and returns in a quadratic program (Markowitz, Freund). Both sufficient conditions for a mean-variance approach have been considered restrictive (Pratt, Arrow). However, Levy and Markowitz recently demonstrated that the mean-variance approach closely approximates a wide range of situations in which these assumptions do not hold and thereby provides renewed justification for its use. The formulation has been increasingly used in firm risk research in agricultural economics (Anderson, Dillon, Hardaker; Robison and Brake). The form of this quadratic program is as follows:

$$\text{(1)} \qquad \text{Maximize } \mathbf{c}'\mathbf{x} - \frac{\alpha}{2}\mathbf{x}'V\mathbf{x},$$

subject to

$$\text{(2)} \qquad A\mathbf{x} \leq \mathbf{b} \quad \text{and}$$

$$\text{(3)} \qquad \mathbf{x} \geq 0,$$

where **x** is a vector of farm activity levels, c is a vector of expected net revenues from **x**, V is a variance-covariance matrix of net revenues from **x**, α is a scaler risk-aversion coefficient, A is a matrix of input-output coefficients, b is a vector of resource constraints, and ′ is the vector transpose operator. One problem in implementing this model is the choice of an appropriate level(s) of α for microapplications. To avoid the questionable methodology for estimation of α (Young 1979, Grether and Plott), this study derived E-V frontiers which are defined as the change of basis solutions when α is parameterized (Sharpe). These frontiers subsume a large number of risk preference situations and therefore provide a more general analysis of the impact of farm programs on resource allocation.

The methodological approach of other E-V studies which include voluntary government programs has been to include both a participating and a nonparticipating activity in the model for each commodity under the government program (Scott and Baker; Persaud and Mapp). However, this procedure can yield solutions which are inconsistent with the cross-compliance provisions of the 1977 Act that requires participation for all commodities. To incorporate this policy limitation in the analysis, this study derived E-V solutions under two situations: (*a*) participation in the 1977 Act for all commodities and (*b*) nonparticipation in the 1977 Act for all commodities. Considerations of incentives for participation were then based on comparisons of the two E-V frontiers.

Empirical Model

The basic model for this study reflected a representative farm firm in South Central Georgia and was adapted from an earlier linear programming study (Johnson, Saunders, Martin).[1] The firm owned 500 acres of land; however, only the 182.6 acres of cropland were incorporated in the model. The firm had a 60.9-acre peanut allotment and a 21.0-acre tobacco allotment. Crop activities include corn, cotton, peanuts, tobacco, soybeans, second-crop soybeans, wheat, oats, and grain sorghum. Cotton and peanuts were both subject to agronomic restrictions. The farm firm was endowed with 2,500 hours of operator labor, and activities were included to allow hiring seasonal labor in five periods subject to a managerial restraint. The budgets for the

[1] More information on the assumptions and sources of data, the synthesized time series in the participating situation, and the structure of the model are available in Stamoulis and Musser and Stamoulis.

crops reflected above-average management and 1978 prices. The constraints, constraint matrix, and objective function for the nonparticipating farm reflected standard methodology in farm organization studies, except the production and marketing functions of the firm were combined into a single activity for each crop. The variance-covariance matrix was estimated with detrended historical data on gross revenues for crop enterprises for 1958–77 (Georgia Crop Reporting Service).[2]

In the participation situation, the basic model was altered to reflect the voluntary commodity programs. The gross revenue for commodities under this Act were estimated as

$$(4)\qquad R_{it} = P_{it}Y_{it} + A_t DP_{it}Y'_{it} + D_{it}Y''_{it},$$

where R_{it} is gross revenue from crop i in year t; P_{it}, higher of market price or loan rate for crop i in year t; Y_{it}, actual yield of crop i in year t; A_t, the allocation factor for year t; DP_{it}, deficiency payment for crop i in year t; Y'_{it}, normal crop yield for crop i in year t; D_{it}, per unit disaster payment rate for crop i in year t; and Y''_{it}, yield eligible for disaster payment in year t. All definitions are on a per acre basis. DP_{it} is defined as

$$(5)\qquad \begin{aligned} DP_{it} &= P'_{it} - P_{it} \quad \text{if } P'_{it} - P_{it} > 0,\\ &= 0 \quad\quad\quad\quad\;\, \text{if } P'_{it} - P_{it} \leq 0, \end{aligned}$$

where P'_{it} is the target price for crop i in year t. Y''_{it} is defined as

(6)

$$\begin{aligned} Y''_{it} &= d_{it}Y'_{it} - Y_{it} \quad \text{if } d_{it}Y'_{it} - Y_{it} > 0,\\ &= 0 \quad\quad\quad\quad\quad\; \text{if } d_{it}Y'_{it} - Y_{it} \leq 0, \end{aligned}$$

where d_{it} is portion of Y'_{it} covered by disaster payments.

This definition does not include all potential program benefits available under the 1977 Act; data limitations precluded inclusion of disaster payments for prevented plantings, and consideration of the potential benefits for participation in the farm reserve programs were beyond the scope of this study. Thus, equation (4) is a minimal estimate of gross revenue under the 1977 Act.

The model for the participating situation reflected the 1978 program. The only differences in net revenue, or the linear portion of the objective function, for participating firms in this year were deficiency payments for grain sorghum and wheat equal to \$20.35 and \$12.25 per acre, respectively. Voluntary diversion activities were included for cotton, corn, and grain sorghum, which were constrained to be 10% of the planted acreage of the respective crop. A normal crop acreage restriction of 124.96 acres was included, which represented the average land area devoted to the crops covered by the provision in South Central Georgia. All of the crop activities except peanuts and tobacco, which were not included in the normal crop acreage, and the diversion activities had an entry in this restriction. The set-aside provision was incorporated in the model by altering the entries for appropriate activities in the cropland and normal crop acreage restrictions to 1.1 for corn and grain sorghum and 1.2 for wheat; cotton did not have a set-aside in 1978.

A major methodological problem in this study concerned the estimation of the variance-covariance matrix for the participating situation. Historical data on the policy variables included in equation (4) did not exist prior to 1977. Elicitation of a subjective variance-covariance matrix (Anderson, Dillon, Hardaker) also did not appear promising because of the difficulties in eliciting covariances reported by Lin, Dean, and Moore, and more general methodological problems with elicitation procedures (Grether and Plott). As a result, a time series of program variables was synthesized from available information. The basic perspective in this methodology was to determine what would have been the values in equation (4) if the 1977 Act had been in effect in previous years. Scott and Baker appear to have used similar methods in estimation of objective function values for their government program activities. However, their methodology is not explicit in their paper.

Specifications of A_t, d_{it}, and Y'_{it} were straightforward; A_t can vary from .8 to 1.0 with the minimum level set annually by the Secretary of Agriculture. A farm can have the maximum amount if acreages are reduced (or not increased in some years) from that of the previous year. Due to the unavailability of

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[2] The variate difference method was used to detrend the data. This method allows the mathematically predictable expected components of the data to be removed and the variances and covariances calculated on the residual random component of the data (Tintner, Carter and Dean). The view that all predictable

levels of .6 for wheat and feed grains and .75 for cotton were assumed for d_{it}. Under the Act, Y'_{it} is specified for individual farms as moving averages of previous yields. In this study, Y'_{it} was calculated using historical data on county average yields in these statutory formulas.

The time series for loan rate, target price, and disaster payment rate were based on the assumption that the provisions of the 1977 Act which mandated that target prices be escalated to reflect increases in variable and fixed costs (excluding land) reflected the current political judgment about relationships between payment levels and costs of production. A time series on cost of production is not available so that the Index of Prices Paid by Farmers for Production Items (USDA) was used as a proxy. The 1978 target price, loan rate, and disaster payment rates were multiplied by the ratio of this index in earlier years to the same index for 1978 to calculate these payment levels for earlier years.[3] Earlier studies that have demonstrated political stability in program benefits for specific commodities support this methodology (Field; Rausser and Freebairn).

The gross revenues for corn, cotton, wheat, and grain sorghum under the 1977 Act were calculated with equation (4) using historical data and the synthesized policy variables. Oats and soybeans were eligible for loans under the 1977 Act, but these estimated loan rates were never higher than market prices so the gross revenue time series was the same as in the nonparticipating situation. The loan rate was used for P_{it} only for cotton in 1966, 1969, and 1970; this result was not surprising since the loan rate is designed to be below market levels. Deficiency payments were included for wheat for the period 1968–72, for cotton in 1966 and 1970–2, and for grain sorghum in 1971–2. Disaster payments were paid for wheat in 1972 and 1974, corn in 1969 and 1977, and cotton in 1968–70. Examination of equation (4) demonstrates that gross revenue per acre would never be less than the nonparticipating situation in the participating situation. The preceding summary of program benefits indicates that gross revenue per acre would have been higher in six years for cotton, six years for wheat, two years for corn, and two years for grain sorghum.

The synthesized time series along with the historical time series for oats, soybeans, peanuts, and tobacco were detrended with the variate difference method and the variance-covariance matrix calculated for the participating situation. The variance-covariance matrix for crop activities used in both situations is presented in table 1. The increases in gross revenues for program crops had the expected effects on variances. The reductions in variance for wheat and grain sorghum are slight; however, the reductions for corn and cotton are quite large. Examination of the variance-covariance matrix also reveals another risk-reducing feature of the government program in this analysis—some of the covariances have dramatic reductions. For example, the covariance between peanuts and cotton is -232 and between peanuts and the program cotton is -653; the covariance between corn and soybeans is 300 and between program corn and soybeans is 56.[4] The shift in covariances suggests that government programs can result in risk reduction associated with diversification in addition to direct reduction in variances.

Model Solutions

Optimal parametric solutions for the nonparticipating and participating situations are presented in tables 2 and 3.[5] The E-V frontiers from these solutions appear in figure 1. The most important result in these solutions is that the participation situation dominates the nonparticipating situation at all expected income levels. While this result can be deduced from tables 2 and 3, it is most apparent in figure 1: the E-V frontier for the participating situation is below the frontier for the nonparticipating

[3] Subsequent to the completion of this empirical research, Miller and Sharples considered methods to index commodity program benefits. One alternative used an index of prices paid adjusted for yield changes. In retrospect, adjustment for productivity changes as reflected in yield increases should have been included in this analysis. However, its exclusion resulted in an upward bias in the program payment rates under the assumption that yields have trended upwards over time. The higher program rates resulted in lower estimates of historical program gross revenues than if yields had been adjusted, which is consistent with the general underestimation of program gross revenues in this analysis.

[4] These reductions in covariances are not solely a result of different scales for the data. The correlation coefficient for gross incomes from cotton and peanuts is reduced from $-.12$ to $-.56$ with program participation and for corn and soybeans from .95 to .39.

[5] Some of the solutions with low risk-aversion coefficients do not fully utilize the available land resources. This outcome is not unusual in E-V analyses and these solutions are sometimes deleted as unrealistic (Persaud and Mapp). However, the large amount of idle cropland and cropland used for pasture and forestry in Georgia (White et al.) suggests that these solutions were relevant.

Table 1. Variance-Covariance Matrix for Gross Incomes per Acre of Crop, 1958–1977

	Corn	Cotton	Peanuts	Tobacco	Wheat	Soybeans	Oats	Grain Sorghum	Program Corn	Program Cotton	Program Wheat	Program Grain Sorghum
Corn	217	17	207	746	363	300	39	108	207	11	40	107
Cotton		4,436	−232	−3,378	704	258	148	1,308	22	4,310	703	1,284
Peanuts			863	5,354	106	155	−111	29	219	−653	−100	25
Tobacco				37,201	−736	973	−816	142	848	−3,407	−646	110
Wheat					190	83	51	242	376	704	190	244
Soybeans						462	66	161	56	248	95	172
Oats							44	27	0	149	50	30
Grain Sorghum								596	104	1,290	249	581
Program Corn									44	4	932	104
Program Cotton										1,595	631	241
Program Wheat											190	250
Program Grain Sorghum												572

Note: These data are rounded values of those used in the model solutions.

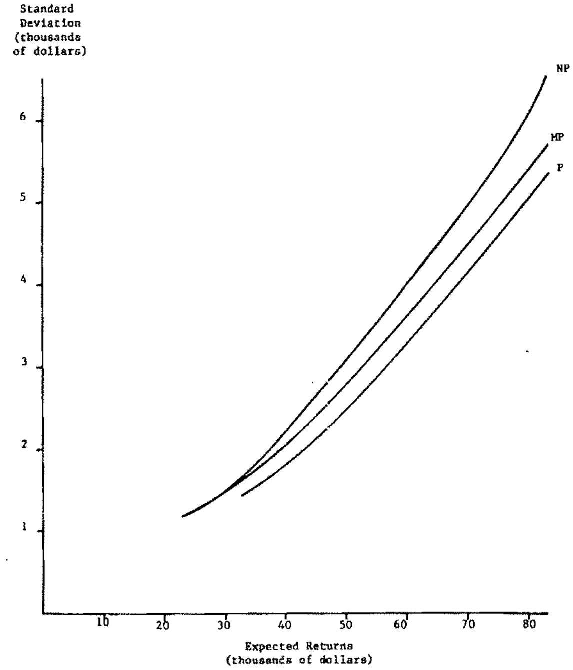

Figure 1. E-V frontiers for a nonparticipating (NP), a modified participating (MP), and a participating (P) farm

situation for all levels of expected returns and widens as the maximum profit solution is approached. These E-V results are consistent with impact of the program on the variance-covariance matrix discussed above.

A modified government participation formulation was constructed to provide an evaluation of the relative importance of the shifts in covariances to the shifts in variance. This formulation was exactly the same as for the participation situation, except that the nonparticipation covariances were included in the model. Solution results for this modified participation formulation are included in figure 1. At low levels of expected income, the variance of net revenue was about the same as the nonparticipating situation, which indicates that the shift in covariances accounted for most of the overall risk reduction at these expected income levels. Above expected income levels of $40,000, the variance of the modified participation solution diverges from the nonparticipation solution; however, the standard deviation of returns at maximum expected net income is $5,631, which is more than $300 above that of the participation situation. Thus, the impact of government programs on covariances of incomes can be quite important for risk reduction. Analyses that consider only

Table 2. Quadratic Risk Programming Solution Levels for a Nonparticipating Farm, Twenty-five Counties in South Central Georgia, 1978

Risk Aversion Coefficient	Expected Returns	Standard Deviation of Returns	Cotton	Peanuts	Tobacco	Soybeans	Oats
	($ thou.)		(acres)				
0.01745	23.044	1.149	.157	44.640		18.580	97.790
0.01520	24.857	1.242	.650	47.590		22.400	89.230
0.01331	28.190	1.419	.742	54.360		25.590	101.910
0.01180	30.400	1.538	1.236	58.210		29.550	93.590
0.01094	31.941	1.624	1.580	60.900		32.320	87.790
0.00707	34.520	1.800	3.147	60.900		49.790	68.770
0.00463	45.466	2.674	8.678	60.900	4.330	54.570	54.120
0.00442	45.938	2.713	8.918	60.900	4.310	58.115	50.355
0.00425	47.197	2.818	9.570	60.900	4.820	58.820	48.490
0.00368	48.929	2.970	10.680	60.900	4.780	71.140	35.099
0.00277	59.182	3.912	16.580	60.900	9.029	81.097	14.990
0.00272	59.598	3.951	16.690	60.900	9.329	79.846	15.837
0.00228	67.782	4.712	21.406	60.900	12.780	87.520	
0.00192	75.976	5.484	26.277	60.900	17.400	78.023	
0.00182	75.979	5.485	26.429	60.900	17.400	77.870	
0.00168	80.071	5.895	28.993	60.900	19.820	72.880	
0.00164	81.734	6.063	29.954	60.90	21.000	57.377	13.378
0.00158	82.055	6.095	30.339	60.90	21.000	70.361	
0.00096	82.118	6.104	32.773	60.90	21.000	67.928	
0.00017	82.843	6.500	60.900	60.90	21.000	39.800	

one commodity can significantly understate the risk-reduction benefits of government programs.

With the shifts in variance-covariance matrices between the two situations, reallocation of resources among crops would be expected. Referring to tables 2 and 3, the same activities appear in the solutions with similar patterns.

Table 3. Quadratic Risk-Programming Solution Levels for a Program-Participating Farm, Twenty-five Counties in South Central Georgia, 1978

Risk Aversion Coefficient	Expected Returns	Standard Deviation of Returns	Program Cotton	Peanuts	Tobacco	Soybeans	Oats	Cotton Division
	($ thou.)		(acres)					
0.01608	32.900	1.430	22.68	59.31		18.32	59.94	2.27
0.01539	33.906	1.474	23.82	60.90		19.49	55.58	2.38
0.01282	34.654	1.510	24.97	60.90		23.59	52.14	2.50
0.00926	36.509	1.620	28.57	60.90		33.74	32.17	2.86
0.00903	37.670	1.697	29.32	60.90	.58	31.18	44.78	2.93
0.00764	42.301	2.000	35.51	60.90	2.35	29.06	43.51	3.55
0.00751	43.099	2.052	36.11	60.90	2.76	27.31	51.89	3.61
0.00664	46.760	2.291	41.12	60.90	4.13	26.07	46.26	4.11
0.00641	47.047	2.310	41.60	60.90	4.12	27.83	43.99	4.16
0.00630	47.440	2.337	42.25	60.90	4.23	28.28	41.02	4.22
0.00528	47.449	2.337	42.26	60.90	4.22	28.38	40.95	4.23
0.00621	47.812	2.362	42.76	60.90	4.37	28.22	40.83	4.28
0.00620	47.841	2.371	42.87	60.90	4.44	27.95	42.15	4.29
0.00502	48.903	2.436	44.23	60.90	4.81	27.68	40.55	4.42
0.00595	49.078	2.448	44.30	60.90	4.92	27.15	40.90	4.43
0.00591	49.082	2.449	44.25	60.90	4.92	27.25	40.85	4.42
0.00524	50.306	2.537	46.50	60.90	4.89	34.16	31.49	4.65
0.00404	59.536	3.238	60.90	60.90	8.63	33.38	12.70	6.09
0.00320	65.885	3.747	60.90	60.90	11.32	43.39		6.09
0.00229	76.480	4.689	60.90	60.90	17.40	37.31		6.09
0.00186	82.455	5.286	60.90	60.90	21.00	33.71		6.09
0.00143	82.843	5.335	60.90	60.90	21.00	39.80		

Solutions with high risk-aversion coefficients include cotton, peanuts, soybeans, and oats. As the risk-aversion coefficient decreases, cotton, peanuts, and soybean levels tend to increase, oats eventually are excluded, and tobacco enters the solution and increases to its maximum level. Differences do exist—soybeans first increase and then decrease and oats reenter the solution when the tobacco allotment constraint first becomes effective in the nonparticipating situation. Another important difference is the level of cotton acreage in the lower part of the participating E-V frontier. For example, the cotton activity was in the solution at 25 acres at expected incomes of about $34,500, and at 61 acres at expected incomes of about $59,500 in the participation situation, while the levels at these expected income levels were 3 acres and 17 acres, respectively, in the nonparticipating situations. Smaller levels of tobacco, soybeans, and oats provided the increased land for cotton in the participating solution. This increased cotton acreage reflects the reduction in risk associated with the government program for this commodity, as no program payments were made for cotton in 1978.

The increased acreage of cotton in the solution and the large reduction in variance of its returns support the view of Gardner and Spitze that the 1977 Act was relatively more favorable for cotton than for other commodities. Two aspects of the solutions indicate that the benefits of the wheat and feed grains program were not so great as for cotton, at least for south central Georgia. First, the benefits of the program were not sufficient to stimulate inclusion of these commodities in the solutions of the participating situations. In addition, program participation reduced the variance of gross returns for wheat and feed grains, but their covariance of returns with other activities in the solution decreased relatively less for these commodities than for cotton (table 1).

The voluntary cotton diversion activity was in all the solutions except the final, profit-maximizing solution. Furthermore, the activity was in all the solutions at their upper level—10% of the cotton activity. Its inclusion in all of these solutions undoubtedly is related to its nonstochastic nature since it was not in the profit-maximizing solution. The shift in the 6.09 acres from voluntary diversion to soybeans in the final solution increased profits about $64 per acre and standard deviation of profits about $400. It also can be noted that the expected returns from the wheat and feed grain voluntary diversion programs were not sufficient to draw these crop activities into the solution.

The existence of no set-aside for cotton in 1978 decreases the generality of the results in tables 1 and 2 because of the importance of the cotton activity in these solutions. With a set-aside in effect for cotton, the program solutions would have less total crop acreage if cotton were included. To explore this possibility, a solution was obtained for a participating situation in which a 10% set-aside was required for cotton. This solution again included the same activities. However, the levels of some activities were lower in most solutions because of the cotton set-aside. The maximum profit solution had a net income of $82,016 and a standard deviation of $5,286 (Stamoulis). As expected, the idle land required for the set-aside resulted in lower net income than in the nonparticipating situation—the final three solutions in the non-participating situation had higher net income than $82,016 (table 2). Achievement of these higher expected profits required a corresponding increase in risk—the standard deviation of returns at maximum profits in the nonparticipating situation was $6,500 (table 2). Unless farmers are risk-neutral or risk seekers, they would be expected to participate in the government program in this representative situation.

Conclusions

This study has provided empirical support for the widely held view that government agricultural commodity programs reduce the risk faced by agricultural producers. In an E-V framework, program participation resulted in lower variance of net income for all levels of net income achievable both with and without program participation for a representative farm situation in south central Georgia in 1978. When a set-aside was required for cotton, slightly higher net income was achievable without participation. The importance of the risk reduction aspects of the program was particularly important in these results because the expected returns of the activities in the solution were the same in both situations. These results imply that farmers represented by this model who have any degree of risk

aversion would have had incentives to participate in the 1978 program.

Available data on program participation in this area in 1979 do not necessarily support this strong conclusion. Using program compliance data for 1978 (Georgia State ASCS Office) and number of farms with crops production in 1974 (U.S. Department of Commerce), 49.4% of the farms participated in the program. The range among counties in the area was 21.9% to 78.3%. The lower level of participation than predicted from the model undoubtedly reflects the high level of cotton production and zero corn production in the solutions. As in the earlier study with this constraint matrix (Johnson, Saunders, Martin), these results are inconsistent with actual production patterns in this area, which included large corn acreage and very small cotton acreage. This divergence from representative data is not uncommon in mathematical programming models and reflects several considerations in this study. Most important, many farmers do not have the management skills required to achieve the level of cotton production reflected in this model or are unwilling to make the specialized investment in a cotton harvester with fluctuating cotton prices. In addition, more stringent rotational constraints and/or land quality constraints would have resulted in a substitution of corn for cotton and soybeans. With more corn in the solutions, the reduction in expected net income because of the corn set-aside would have decreased incentives for participation. Analysis of the impact of a cotton set-aside indicated that the basic results of the analysis if more corn was in the solution would still hold except that higher expected returns would be achievable without participation, so that risk-neutral producers, and probably even those with low positive risk-aversion coefficients, would have incentives not to participate.

While generalization of results from representative farm situations is not usually possible, some implications of the study are likely to hold in other geographical and temporal situations. Most important, the decision to participate in voluntary farm commodity programs involves the familiar risk-returns trade-off—participation will reduce expected net returns and also risk. The trade-off arises because the opportunity cost of the land required for the set-aside is higher than the income benefits of the program, particularly if land resources are homogenous and have high productivity. The normative side of this implication is that participation in voluntary programs with payment levels such as the 1977 Act likely will be optimal for risk-averse producers; producers with higher risk-aversion coefficients, and/or more business and financial risks will more likely participate. These implications are consistent with the microstudies in other geographical areas (Scott and Baker, Kramer and Pope, Persaud and Mapp).

The study also suggests some implications for interaction between commodity program features and likely participation in certain situations. Most obviously, the level of set-aside will affect participation. With a zero set-aside, the risk reduction aspects of the program are available with zero opportunity costs. A related implication is that level of opportunity costs of the set-aside is likely to be inversely related to participation. In areas with higher quality land than in Georgia, the divergence between maximum expected incomes caused by the set-aside likely will be higher. An additional implication is that the risk-reduction benefits of the wheat and feed grain programs are generally less than for cotton, so that the incentives for participation likely would be less for situations in which these crops are more important. However, this proposition may not hold for situations in areas where wheat and feed grains are subject to more income risk than in south Georgia. Finally, the normal crop acreage restriction likely would be more limiting in situations with adjustable acreages of crops not included in the restriction; the government program would involve larger risk-returns trade-offs in situations in which land was being transferred from hay, pasture, or horticultural crops to field crops.

The policy implications of this research are further supported by the overall tendency of the methodology to underestimate the times series of gross income from program participation. Payments for prevented plantings and benefits of the farmer reserve program were not considered in the analysis. Assuming the minimum value of the allocation factor also reduced the level of deficiency payments. In addition, market prices in the period from 1958–65 reflected higher price supports than under the 1977 Act, which resulted in no government program benefits during this period in the participating time series. A time series of participating gross revenues that did not in-

clude these underestimation features undoubtedly would have small variances and even more risk reduction than indicated in this analysis.

The analysis in this paper also has some methodological implications. Most important, analysis of the impact of variation in program benefits and requirements on the incentives to participate in government programs needs to be in an expected utility framework. This implication arises from the view that farm income stability has always been an important goal of farm policy, and the results of this study support the view that currently it is the most important benefit for farmers. Risk-return analysis of farm commodity programs also must allow evaluation of the resource reallocation in response to the portfolio effects of the program. In this paper, the shift in covariances between crop incomes was as important as the direct reduction in variance of income from cotton. However, more research in other areas is necessary to determine the generality of this effect on covariances. A broader methodological implication is that synthesizing a time series to estimate variance-covariance matrices is a potentially useful alternative to subjective elicitation when historical data are available and bears attention in future research.

Further empirical research on the issue of risk reduction from government commodity programs is warranted. More research for other microsituations would be helpful in validating the implications of this paper. In addition, such research should consider incorporating the aspects of commodity program excluded from this analysis. For example, an expanded model could include marketing activities to allow consideration of the farmer reserve program. Consideration of alternative policy deflation (inflation) methods would be directly helpful in designing farm commodity legislation. Finally, methodologies other than risk programming may be appropriate to accommodate some of the limitations of this methodology (Robison and Brake).

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Forecasting Short-Run Fed Beef Supplies with Estimated Data

James N. Trapp

Unknown aggregate data series for the placement weight, growth rate, and sex composition of cattle placed on feed are estimated. The estimates are made by treating the unknown data as time-varying parameters of a cattle-on-feed growth and inventory stimulation model. A nonlinear optimization algorithm is used to estimate the unknown parameter series that optimize the model's simulation accuracy. Incorporation of the estimated series into a traditional econometric fed-beef-supply forecast model improved the model's forecast accuracy. The methodology used provides a general procedure for estimating unknown aggregate data using simulation models based upon microrelationships.

Key words: beef supply, forecasting, nonlinear optimization, parameter estimation, simulation.

Agricultural economics research often is hampered by a lack of appropriate data. In such cases researchers have either ignored the relations described by the missing data or attempted to develop a proxy for them, hoping that some consideration of these relations is better than ignoring them. Keith and Purcell point out that voids exist in U.S. Department of Agriculture (USDA) cattle slaughter data, making it impossible to trace cattle inventories from birth to death. This hampers analyses of the cattle cycle and forecasts of beef supplies.

A common traditional model used by outlook economists in making short-run fed-beef supply forecasts illustrates the limitations created by voids in physical data describing cattle on feed. The model regresses fed beef slaughter one to two quarters in advance upon current cattle-on-feed numbers by weight groupings. Such forecasts either ignore or crudely approximate known information about beef growth relationships; i.e., variations in growth rates due to seasonal weather conditions are proxied by dummy variables; changes in growth rates due to improved breeding, feed additives, and other factors are ignored; effects of the animals' placement weights upon their growth rates, eventual slaughter weights, and dates of slaughter also are ignored.

It is the premise of this research that an objective method of estimating aggregate physical data series for cattle on feed, such as placement weights and growth rates of cattle on feed, coupled with knowledge of the beef growth process, can provide information beneficial to short-run fed-beef supply forecasting. Consider a short-run, fed beef-forecasting model of the following form:

$$(1) \qquad \text{fed beef supply} = f(\mathbf{X}, \quad \hat{\mathbf{U}}),$$

where $\mathbf{X}$ is a vector of observable variables and $\hat{\mathbf{U}}$ is a vector of estimated values for unobserved, but relevant, physical data. The methodology developed here estimates the unknown physical data series $\hat{U}$ as a set of time-varying parameters of a growth and inventory simulation model of cattle on feed. As a simplified example, consider

$$(2) \quad Y700_t = g(Y700_{t-1}, \quad Y500_{t-1}, \hat{U}1_t, \hat{U}2_t, T),$$

where $Y700_t$ represents the reported number of 700–899-pound steers on feed at time t; $Y500_{t-1}$, the number of 500–699-pound steers on feed the previous period; and likewise $Y700_{t-1}$, the number of 700–899-pound steers on feed the previous period. $\hat{U}1_t$ and $\hat{U}2_t$ represent specific time-varying parameters of the general vector $\hat{\mathbf{U}}$ above. In this case $\hat{U}1_t$ represents the number of 700–899-pound steers

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placed on feed during period t, and $\hat{U}2_t$ the daily growth rate of steers, while T is the number of days between t and $t-1$.

Within the model structure, given $Y700_{t-1}$ and $Y500_{t-1}$, alternative values for $\hat{U}1_t$ and $\hat{U}2_t$ can be used to simulate the number of steers entering and exiting the $Y700_t$-weight group of cattle and hence its inventory state at time t. Based upon this structure, $\hat{U}1_t$ and $\hat{U}2_t$ can be estimated with the objective of accurately simulating $Y700_t$. The unknown physical data series to be estimated in this study include (*a*) the average growth rate of cattle on feed, (*b*) the placement weight of cattle on feed, and (*c*) the sex of cattle placed on feed.

The growth and inventory simulation model for which the unknown physical data series were estimated is based upon an individual animal growth model. However, because the data series desired are aggregate in nature, the individual animal growth model was not used directly, but its basic concepts were used to develop an aggregate model. The physical data series estimated have been incorporated into an econometric fed-beef-forecasting model with beneficial results. This general methodology may be of use elsewhere when lack of data hampers research.

Growth and Inventory Model for Cattle on Feed

The basic structure of the growth and inventory model for cattle on feed is shown in figures 1 and 2. As depicted in figure 1, the model contains seventeen inventory categories, three placement weight alternatives for steers, and three for heifers. A uniform distribution of placement weights for cattle in each weight category is assumed, while the distribution among categories is left to be estimated.[1]

Each placement weight alternative results in a unique growth path and slaughter weight. Figure 2 depicts a typical set of growth paths and slaughter weights for steers placed at dif-

[1] It is assumed that no steers weighing less than 350 nor more than 899 pounds and no heifers weighing less than 300 nor more than 899 pounds are placed on feed.

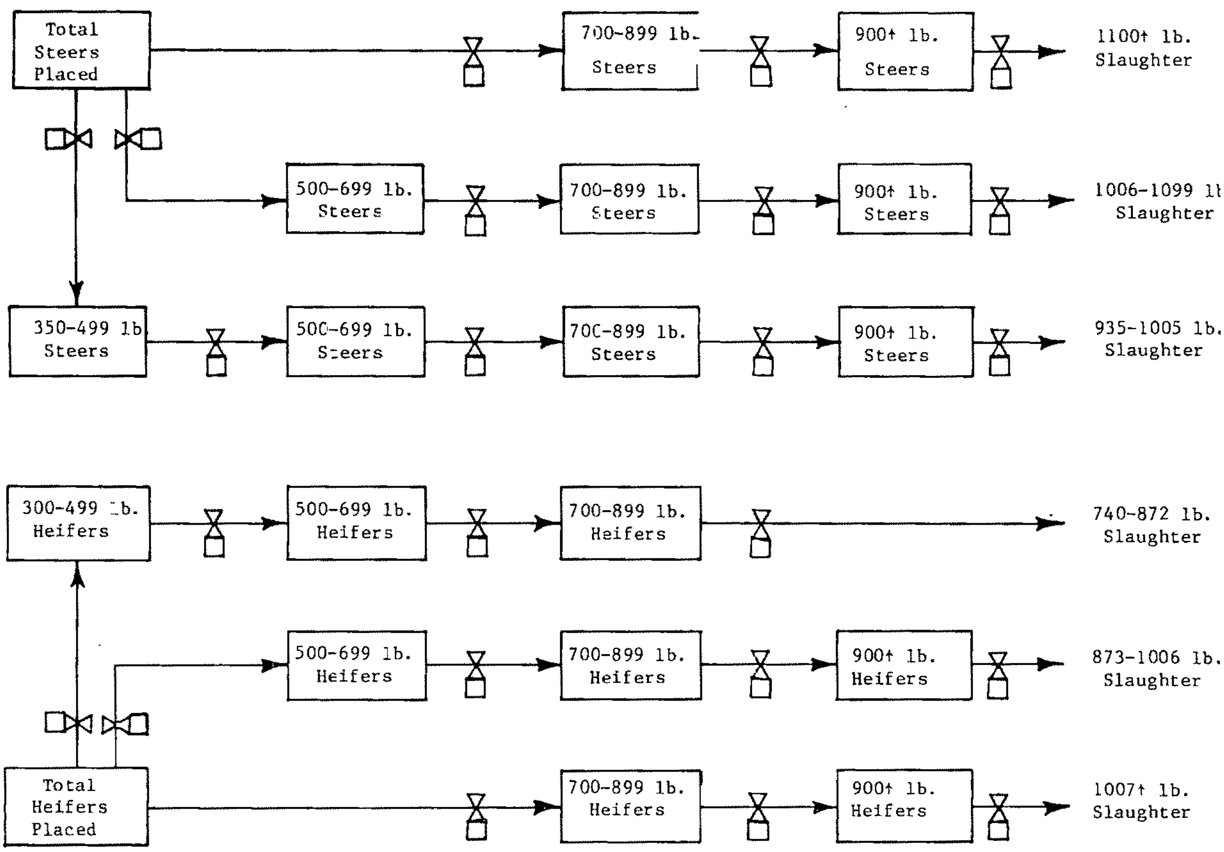

Figure 1. Growth and inventory model for cattle on feed

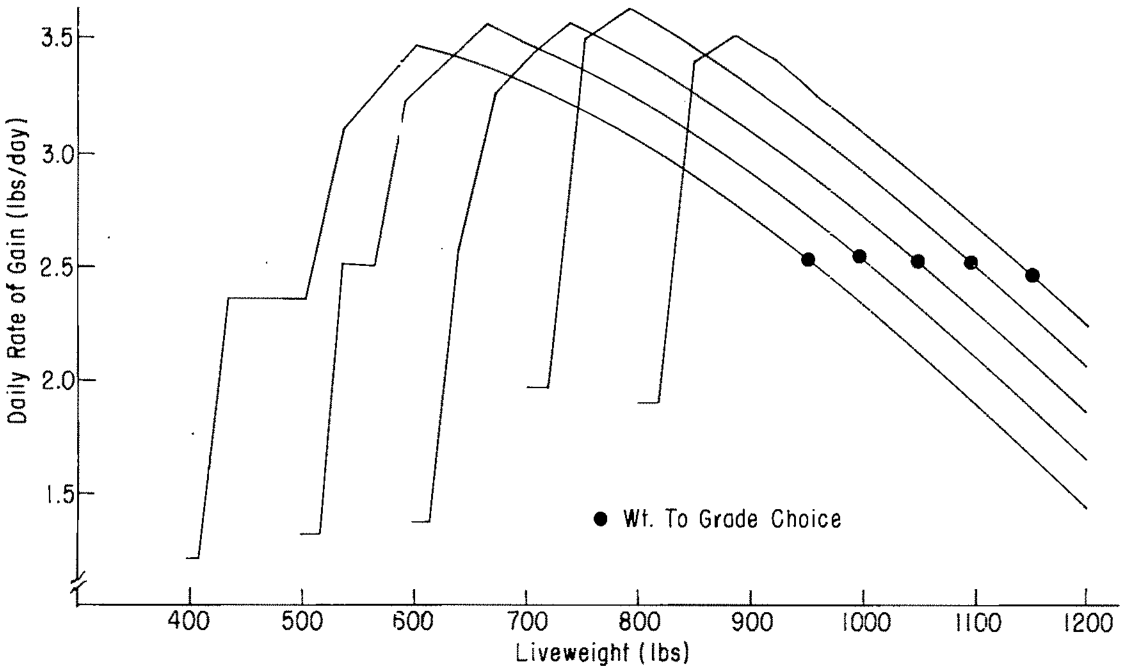

Figure 2. Typical daily rates of gain for steers by placement weight and current weight

ferent weights.[2] A similar set of curves can be developed for heifers. Figure 2 is derived from a biological growth model of a beef animal developed by Nelson. His work draws heavily upon that of Gill and Lofgreen and Garrett and is similar to that of Fox and Black.

The growth patterns and inventory categories depicted in figures 1 and 2 are incorporated into a computerized growth and inventory simulation model for cattle on feed. A modified version of a continuous distributed delay subroutine developed by Pugh is used to simulate the growth and inventory process for each of the seventeen inventory groups. This subroutine is capable of simulating the daily flow of cattle into and out of each given inventory category and of maintaining an inventory count for each category. Parameters required to accomplish this include the average daily growth rate of animals in the category, the weight range of the category, and the daily number and weight of animals entering the category. The growth and inventory model for cattle on feed is a collection of seventeen such subroutines linked together; i.e., the simulated outflow of the delay model describing the 350–499-pound steer inventory category is the input to the delay model for the 500-699-pound steer inventory category in the lightest steer placement-weight growth path.

The growth curves depicted in figure 2 for steers and a similar set of curves derived for heifers (from Nelson's model) are used to specify the relative growth rate relations among the seventeen inventory groups while the general rate of growth is estimated. Thus, a single-valued shifter of the curves depicted in figure 2 is estimated. It decreases or increases the base set of assumed growth curves, but does not alter the relations between the curves.

Estimation of the Unknown Physical Data Series

The unknown data series to be estimated are time-varying parameters of the distributed delay model. They are the general growth rate of animals on feed, the weight category within which animals are placed, and the sex of animals. The task specified for the estimation procedure is to determine the set of unknown parameters which will result in the most accurate simulation of the reported quarterly data of historical cattle on feed and marketings. The objective function consists of the weighted sum of squared errors in predicting nine inventory levels, the total number of cattle on

[2] The distinct discontinuities observed in the 400- and 500-pound beginning weight curves are due to assumed ration changes which disrupt feeding and growth patterns for brief intervals.

feed, and fed cattle marketed. This function is minimized each quarter to generate one set of time-varying parameter estimates.

$$
\begin{aligned}
(3)\quad OBJ = {} & ESTEER^2(350\text{–}499) \\
& + ESTEER^2\,(500\text{–}699) \\
& + ESTEER^2(700\text{–}899) \\
& + ESTEER^2(900\text{–}1{,}099) \\
& + ESTEER^2(1{,}100 \text{ and above}) \\
& + EHEIF^2(300\text{–}499) \\
& + EHEIF^2(500\text{–}699) \\
& + EHEIF^2(700\text{–}899) \\
& + EHEIF^2(900 \text{ and above}) \\
& + 9 *ECOF^2 + EMARKET^2,
\end{aligned}
$$

where OBJ is the sum of squared-errors objective value to be minimized; $ESTEER^2(I-J)$ is the square of the difference (error) between the reported and estimated numbers of steers on feed in weight category $I-J$, i.e., 499 pounds and below, 500–699 pounds, 700–899 pounds, 900–1,099 pounds, and 1,100 pounds and above; $EHEIF^2(I-J)$ is the square of the difference (error) between the reported and estimated number of heifers on feed in weight category $I-J$, i.e., 499 pounds and below, 500–699 pounds, 700–899 pounds, and 900 pounds and above; $ECOF^2$ is the square of the difference (error) between the reported and estimated numbers of cattle on feed at the end of the quarter; and $EMARKET^2$ is the square of the difference (error) between the reported and estimated numbers of fed cattle marketed during the quarter. The error in estimating total cattle on feed is weighted nine times more than other errors since it is the summation of nine weight categories.

Estimation of the time-varying input parameters is conducted as a nonlinear optimization problem. (For a detailed discussion of this estimation procedure, see Richardson, Ray, Trapp.) The nonlinear optimization algorithm used was developed by Box and is referred to as the "Complex Algorithm." It consists of a heuristic search procedure capable of finding the minimum or maximum value of a nonlinear objective function subject to nonlinear constraints.

To estimate a series of time-varying parameters, values for each quarter are considered in sequence. At the end of each quarter, any errors in estimating the size and weight distribution of the ending inventory of cattle on feed are corrected by using data reported in *Cattle on Feed*. Hence, previous errors will not affect parameter estimates for the following quarter.

The simulation accuracy achieved with the growth and inventory model using the time-varying parameters estimated was quite good over the period 1960–1978. The R^2 for simulating the number of cattle on feed was .99, with an average percentage error of 1.57%. The largest single percentage error was 6.76%. The R^2 for simulating the number of cattle on feed marketed was .98, with an average percentage error of 2.86%. The largest single error was 14.17%.

Estimated Data Obtained

Operation of the model and optimization algorithm over the period 1960–78 yielded time-series estimates of placement weight, sex of animals placed, and average aggregate growth rates. Tables 1 and 2 report average seasonal patterns and annual averages for these data series over the period 1960–78.

Growth rates are estimated to be most rapid in the first and fourth quarter and slowest in the third quarter. Seasonal fluctuation is due both to climatic factors and the type of backgrounding received by cattle placed at different seasons. The steer/heifer ratio (sex ratio) of cattle placed on feed indicates that proportionately fewer heifers are placed on feed in the first and fourth quarters. Last, the estimates of the average weight of cattle on feed (which is not an estimated variable but a descriptive output of the model) indicates that the heaviest average weight of cattle on feed occurs in the second quarter and the lightest in the fourth. The seasonal pattern of the average weight of cattle on feed is correlated with the seasonal pattern for number of animals placed and with the average weight of animals placed.

The placement weight information generated by the model is perhaps the most useful. The estimates indicate that a significant portion of cattle placed weigh less than 500

Table 1. Selected Average Estimated Characteristics of Cattle on Feed and Placed on Feed by Quarter, 1960–1978

Quarter	Growth Rate Index	Sex Ratio of Cattle Placed on Feed Steers/Heifers	Average Weight of Cattle on Feed
1	104	3.20	815
2	100	2.15	834
3	89	1.92	821
4	105	2.24	768

Table 2. Estimated Seasonal Distribution of Average Weight and Numbers of Cattle Placed on Feed, 1960–1978

	Percentage Placed				
Quarter	Under 500 lbs.	500–699 lbs.	700–899 lbs.	Average Placement Weight	Index of No. of Cattle Placed on Feed
1	53.2	40.3	6.6	518	85
2	26.7	66.3	7.6	571	83
3	26.5	43.7	29.8	612	97
4	64.4	26.5	9.1	502	135
Annual avg.	42.2	44.5	13.2	549	100

pounds, i.e., 42.2% (table 2). This is not surprising because the turnover rate of cattle on feed under 500 pounds is the most rapid of any reported weight group. Cattle typically gain only 50–75 pounds while in this weight classification, compared to 200 pounds in others. Hence, to maintain a given inventory of cattle on feed under 500 pounds requires more placements than to maintain the same inventory in other weight classes where the turnover rate is three to four times slower.

The estimates reported in table 2 indicate that the majority of the placements under 500 pounds occur during the first and fourth quarters. The heaviest average placement weights occur in the second and third quarters. The largest percentage of cattle (66%) placed in the second quarter is in the 500–699-pound range. This group likely consists of spring calves that have been wintered, grazed on spring pasture, and sent to feedlots.

The time-series paths of the annual average values found for the estimated variables are presented in figures 3A–3C. The sex ratio (fig. 3A) is correlated with the cattle cycle (fig. 3D) measured as the annual index of the rate of change in the size of the cow herd. The simple correlation coefficient (r) is +.67. The sex ratio appears to rise during periods of expansion because more heifers are held for replacements, thus causing the steer/heifer ratio to rise.

The placement weight series is not strongly correlated with the cattle cycle but does appear to be cyclical. During 1974 and 1975, when feed prices were high relative to cattle prices and "grass fed" beef was common, estimated placement weights were the highest observed for the period, 1960–78.

The index of growth rates, figure 3C, does not seem to follow the cattle cycle. When re-

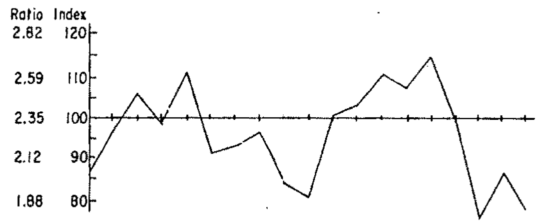

Figure 3A. Steer/heifer sex ratio of cattle placed on feed, 1960–1978

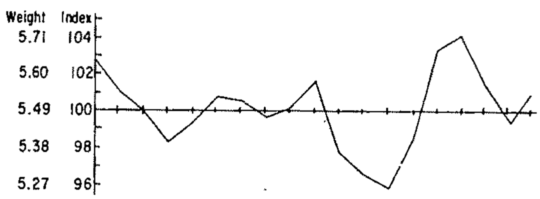

Figure 3B. Average weight of cattle placed on feed, 1960–1978

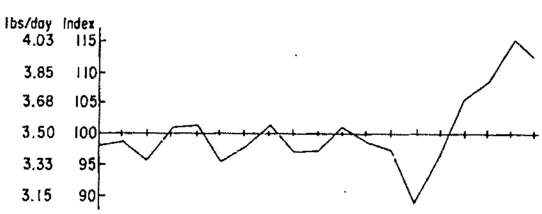

Figure 3C. Daily growth rates for 900-pound steers on feed, 1960–1978

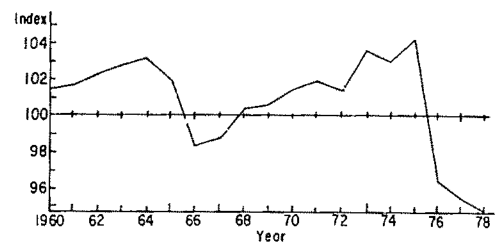

Figure 3D. Rate of change in size of the beef cow herd, 1960–1978

gressed against time, it shows a significant positive trend, primarily due to the unprecedented rise in growth rates since 1973. The drop in growth rates observed from 1970 to 1973 may have been due to the legal actions taken against some growth hormones and feed additives. The rapid estimated increases in the growth rates of cattle on feed since 1973 are sustained by observations of animal scientists. They attribute much of this rise to increased cross-breeding and the development of alternative legal hormones and feed additives.

Application of Estimated Data

Two econometric forecasting models were developed, one that directly incorporates the estimated data and a second based upon proxy variables for the estimated data. The first is a respecification of the "traditional" single-equation, short-run, cattle-on-feed-marketing-forecast model mentioned earlier. This traditional model was respecified to incorporate the data derived in the previous section in the form of three quarterly, seasonally adjusted indices. They are indices of growth rates, slaughter weights, and placement weights. The second forecast model is similar to the first, except that the three indices used in the first model are replaced by proxy variables developed from reported cattle-on-feed data.

Model 1

Three seasonally adjusted, quarterly indices based upon the estimated data are incorporated into Model 1. The indices include a growth rate index constructed by seasonally adjusting the quarterly growth rates for 900-pound steers,[3] an index of slaughter weights formed by calculating a seasonally adjusted, weighted-average index of steer and heifer slaughter weights,[4] and an index of placement weights designed to describe the seasonally adjusted variation in placement weights of steers and heifers on feed and currently weighing over 900 and 700 pounds, respectively.[5]

All three of the indices as used in the model are either lagged or based upon lagged data. Therefore, the data required to calculate the indices and make forecasts are available upon the release of the USDA cattle-on-feed report early in the quarter being forecasted. Lagged, as opposed to current period values of the indices, were used to facilitate forecasting. First-order autocorrelations (R^2) of the indices are approximately .7, making one-period lags of each indice a reasonably good proxy for its current period value.

Ordinary least squares estimates of the "traditional" and new Model 1 over the period 1960–76 are reported in table 3. In general, the statistical properties of Model 1 appear superior to those of the traditional model. The three added variables are each significant at the .025 level or better. The estimated standard error of Model 1 is 24.3% less than that of the traditional model. The traditional model left 10.4% of the variation in fed cattle marketings unexplained compared with 5.7% for Model 1. The presence of the three index variables in Model 1 appears to improve the specification of the model by removing a significant amount of serial correlation.

Each of the coefficients for the lagged indices added to Model 1 displays a plausible sign if they are proxies of the current period value. A positive sign is expected for the coefficient on the growth rate index because faster growth rates would be expected to decrease the remaining time on feed of a group of cattle nearing slaughter weight. Increases in slaughter weight, *ceteris paribus*, would extend the time cattle are on feed and thus reduce the flow of slaughter. Hence a negative sign is expected for the coefficient of the slaughter weight index.

Deducing the plausible sign for the placement-weight index coefficient is more difficult. The physical growth relations of figure 2 indicate that placement weight affects both the slaughter weight and growth rate of steers on feed. The increase in slaughter weights associated with heavier placement

[3] Since growth rates for all sex and weight categories of animals included in the beef simulation model are held in fixed ratios to each other, the specific weight-sex category chosen does not affect the values derived for the index.

[4] The index of slaughter weights was formed by calculating a seasonally adjusted, weighted-average index of steer and heifer slaughter weights. Relative weights for the averaging process were based upon the number of fed steers and heifers estimated by the cattle-on-feed model to have been slaughtered during the quarter.

[5] The index of placement weights was formed by calculating the weighted-average weight of four lagged categories of steer placements and three lagged categories of heifer placements. Lagged placement weight groups included were two-quarter lags for (*a*) 350–499-pound steers, (*b*) 500–699-pound steers, and (*c*) 300–499-pound heifers. One-quarter lags were included for (*a*) 500–699-pound steers, (*b*) 700–899-pound steers, (*c*) 500–699-pound heifers, and (*d*) 700–899-pound heifers.

Table 3. Three Quarterly Beef Supply Forecast Models

Variable	Traditional Model	Model 1	Model 2
Intercept	822.46	17643.80	10206.80
	(3.45)[a]	(6.87)	(3.69)
Steers on feed over 900 lbs. at beginning of quarter	0.61	0.89	0.58
	(3.58)	(5.59)	(3.80)
Heifers on feed over 700 lbs. at beginning of quarter	2.12	1.60	2.06
	(8.30)	(6.97)	(7.98)
Index of seasonally adjusted slaughter weights lagged 1 quarter[b]		−180.66	
		(6.60)	
Index of seasonally adjusted growth rates lagged 1 quarter[b]		27.24	
		(3.48)	
Index of seasonally adjusted placement weights[b]		−14.78	
		(2.00)	
Index of seasonally adjusted steer slaughter weights lagged 1 quarter[c]			−93.68
			(3.59)
Index of seasonally adjusted growth rate proxy ratio lagged 1 quarter[c]			−0.07
			(0.39)
Index of seasonally adjusted placement weight proxy ratio lagged 1 quarter[c]			2151.33
			(1.01)
2nd quarter seasonal dummy variable	433.88	392.52	440.90
	(3.32)	(5.93)	(3.71)
3rd quarter seasonal dummy variable	−369.05	−354.64	−254.47
	(2.52)	(3.10)	(1.17)
4th quarter seasonal dummy variable	−352.73	−250.35	−396.67
	(2.80)	(2.55)	(1.49)
R^2	.896	.943	.934
$\bar{R}^2$	.888	.934	.924
Standard error of the estimate	357.0	270.4	289.2
F-value	103.9	112.4	87.1
Durbin Watson	.433	1.382	1.079
Observations	66	65	65

[a] Values in parenthesis are t-values.
[b] These indices are derived from data estimated in this study.
[c] These indices are derived from reported data.

weights tends to dominate the effect of the increase in growth rates also associated with heavier placement weights. Hence, cattle placed on feed at heavier weights tend to spend more days on feed after they reach 900 pounds than cattle placed at lighter weights. Therefore, it follows that the expected sign for the placement weight index coefficient is negative.

Model 2

The specification of Model 2 was prompted by the success of Model 1. Model 2 uses indices which proxy those of Model 1 but which can be developed from reported, rather than estimated, data. The index of average steer and heifer slaughter weights used in Model 1 is proxied by a seasonally adjusted index of steer slaughter weights. To proxy the placement weight index, a seasonally adjusted index of the ratio of the number of cattle on feed under 500 pounds versus the number over 500 pounds is developed. It is hypothesized that increases in the number of cattle on feed under 500 pounds relative to other weights reflects a decline in placement weights. Last, the index of growth rates is proxied by a seasonally adjusted ratio consisting of the sum of the number of steers on feed over 900 pounds plus the number of heifers over 700 pounds at the beginning of each quarter divided by the number of cattle marketed during the quarter. It is hypothesized that a decrease in this ratio reflects an increase in the growth rate of cattle on feed. The more rapid the growth rate the

more cattle will be marketed during the quarter, relative to the initial number of heavier weight cattle on feed. Lagged values of these three indices are used in Model 2. The estimated model is reported in table 3.

Comparison of Model Forecasts

Ex post forecasts for 1977 and 1978 from the traditional model, Model 1, and Model 2 are presented and compared in table 4, with actual data and estimated marketing intentions determined by the USDA from its quarterly survey of cattle feeders in twenty-three states. Model 1 provides the best set of forecasts and is a distinct improvement over the traditional model. Model 2, which uses only reported data, is also more accurate than the traditional model but not as accurate as Model 1.

The forecasts generated by Model 1 have almost identical accuracy to estimated marketing intentions as reported by the USDA and based upon its quarterly survey of cattle feeders. Note that Model 1 does not use any information from the 1977–1978 period to adjust its parameter estimates. If the parameters of Model 1 are updated over the 1977–1978 period and forecasts made with the updated parameters, the model's root mean squared error, mean absolute error, and Theil inequality coefficient become 164.5, 135.9, and .0127. These values are slightly superior in each case to those of the reported marketings intentions series.

Summary

This study illustrates methodology for estimating physical data series for cattle on feed which are not currently reported by the USDA. Incorporation of the estimated physical data series in an econometric fed-beef supply-forecasting model results in improved accuracy of short-term fed-beef supply forecasts. Each of the estimated data series, when incorporated into the model, generates estimated parameters with expected signs and a high degree of statistical significance. The estimated physical data series obtained also were useful in developing a deeper understanding of seasonal and year-to-year historical changes in growth and slaughter patterns for cattle on feed.

The methodology developed appears to be potentially useful in many areas of agricultural research. Specifically, it appears possible to estimate unreported aggregate-average physical data series from knowledge of microphysical relationships. In this study, microphysical relationships were used to specify the structure of an aggregate cattle-on-feed growth and inventory model. Unknown time-varying physical parameters of this model were then estimated via optimization of the model's simulation accuracy. It is possible to revise and/or expand the growth and inventory model for cattle on feed so that other types of information, in the form of estimated time-varying parameter data series, can be obtained. Such information might include the

Table 4. Comparisons of *Ex Post* Forecasts of Three Cattle on Feed-Marketings Forecast Models with Actual and Reported Marketing Intentions Data

Year-Quarter	Reported Number of Cattle on Feed Marketed	USDA Intentions Survey[a]	Traditional Model	Model 1	Model 2
1977-1	6,462	6,111	6,954	6,138	6,384
1977-2	6,147	6,001	6,493	6,373	6,290
1977-3	6,159	6,043	6,505	6,157	6,337
1977-4	6,093	5,842	6,111	5,963	5,884
1978-1	6,773	6,541	6,996	6,708	6,781
1978-2	6,591	6,565	7,200	6,902	7,158
1978-3	6,536	6,595	7,110	6,728	7,205
1978-4	6,730	6,614	7,257	6,722	6,865
Root-mean-squared-error		190.8	434.3	197.2	333.2
Mean absolute error		161.5	391.7	159.3	248.2
Thiel's inequality coefficient		.0149	.0327	.0153	.0255

[a] Intended marketings during the quarter as estimated from a survey of cattle feeders in twenty-three states and reported in *Cattle on Feed*.

feed consumption of cattle on feed, placements of cattle on grass, aggregate grass-fed-beef growth rates, and seasonal calving patterns of the national cow herd. Attempts to determine what factors explain the variation in the estimated data series appear to hold promise for developing a deeper understanding of fed-beef supply forecasting. With suitable modifications, the methodological approach and the model developed probably can be used in analysis of production and supply of other types of livestock.

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Portfolio Theory and the Demand for Futures: The Case of California Cotton

Peter Berck

This paper examines the simultaneous choice of cropping pattern and futures positions. It derives the demand for hedging as a function of the price of a hedge and the crop choice set; it estimates these functions for California cotton farmers. It finds that both the costs of hedging and the opportunity to diversify risk by growing other crops substantially change the optimal hedge for California cotton farmers.

Key words: cotton, finance futures.

Farmers and inventory holders both can use futures markets to reduce risk. However, a survey by the Commodity Futures Trade Commission (CFTC) shows that only 5% of farmers participate directly in futures markets and as many as a third do not know how the markets work. From its survey, the CFTC concluded that it should provide more education to farmers so that more farmers would hedge. The CFTC's conclusion is not justified because the economic interest of farmers may not lie in their use of futures markets. The purpose of this paper is to lay out the factors that influence farmer hedging and to estimate their empirical importance.

The basic framework is a mean-variance portfolio analysis which is the same framework as that used by Peck, Rolfo, or Rutledge. The model differs from that of Peck or Rutledge because they assume hedging is costless, but we settle the hedging cost empirically. The model differs from that of all three previous authors in the simultaneous choice of both crops and futures. This approach consolidates the choice of the crops approach of Freund; Carter and Dean; and Lin, Dean, and Moore, with the choice of futures approach of Peck, Rolfo, and Rutledge. Both allowing for a risk premium and simultaneously choosing crops and futures make large differences in the optimal hedge and in the location of the mean-variance frontier.

The remainder of the paper is in four sections. The theory section sets out the objective function and constraint set. It presents a formal optimization model. In the second section I discuss the estimation of the means and variances of crop futures returns. In the third section, the empirical results include (*a*) a description of the mean-variance frontier, (*b*) the choice of an efficient plan, (*c*) the benefits of diversification, (*d*) the effects of diversification on hedging, (*e*) the effects of changing the price of a hedge, and (*f*) the effects of forecasting. The conclusions are presented in the final section.

Theory

The discussion of the farmers' portfolio problem proceeds by stating the objective function, defining the constraint set, and deriving the Kuhn-Tucker conditions for a maximum. In passing, the discussion makes six important points: (*a*) farmers make simultaneous decisions on crops and futures; (*b*) they evaluate losses differently than gains (skewness); (*c*) futures holdings tie up their credit; (*d*) mortgages leave them leveraged; (*e*) hedging results in an expected loss; and (*f*) forecasting allows a gain on futures.

For computational ease, most authors in finance literature (Tobin, Markowitz, and

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Sharpe) and in futures literature (Peck, Rolfo, and Rutledge) approximate a more general expected utility objective function with a two-period, mean-variance framework. The approximation does not allow for plan revision, restricts the form of the utility function, and ignores skewness. We treat these items in turn. Plan revision—changing the quantity hedged—should occur as the growing season progresses and yields become more certain. Although Samuelson provides a more general control model for such a situation, it was not adopted for computational reasons. Restricting the utility function to generalized mean variance—$U(M, V)$, increasing in mean, M, and decreasing in variance, V—permits close approximation of the other utility functions common in finance (Levy and Markowitz) and permits a two-stage computation procedure. First, the mean-variance frontier—the locus of minimum variance for given mean—is computed. Then, any $U(M, V)$ function can be used to pick a point on the frontier. The major drawback to the use of mean-variance analysis in agriculture is that yields are known to have skewed distributions (Day) which might distort the ability of variance to represent downside risk. A Chebychev inequality on semivariance is used to check on the effect of nonsymmetric distributions on portfolio choice.

The constraints on wealth (or credit) and land define the farmer's choice set. A farmer has fixed acreage L, debt D, and allocatable credit (and wealth) W. The L acres are split among crops with acreage, A_i, or left idle. In a vector notation, let $\mathbf{A}' = (A_1, \ldots, A_n)$ and $\mathbf{a}' = (1, \ldots, 1)$ so

$$(1) \qquad \mathbf{a}'\mathbf{A} \leq L.$$

Allocatable credit, W, is split between futures, F_i, that tie up f_i dollars each or is unused, B. Each futures impinges on the credit constraint by the maximum amount the farmer is prepared to lose on that contract (worst possible variation margin) and the initial margin. Again, utilizing vector notation,

$$(2) \qquad W \geq \mathbf{f}'\mathbf{F} + B.$$

More generally, wealth could have been allocated to financial assets other than the implicit bond, B, which pays off rB in period two, or to futures. Stocks, options, city real estate, or any other asset could be included.

After a farmer has chosen A and F, the state of nature—which is the profitability of the crops, x, and the gains or losses from the futures positions, z—is revealed. The returns from a futures position are the brokerage fees and interest on margin, which are likely to be small,[1] and the loss (or gain) from the futures position itself. Without predictive ability on the part of farmers, the Keynes-Hicks-Cootner theory of speculative markets holds that storers and producers of commodities will pay speculators to take the price risk of holding commodities. Indeed, this loss on futures, which can run several cents per pound for cotton (and is assumed away in Peck's work on eggs), provides a major reason for farmers not to hedge.[2] On the contrary, if farmers have good predictive ability, then they may enter the futures market for the same reason as speculators—to make an (expected) profit on their futures position.

The farmer's second-period income, Y, is composed of profits from crops, losses (or profits) from futures, interest cost on credit, interest paid on deposits, and interest paid on fixed debt:

$$(3) \qquad Y = x'A + z'F + rB - rD.$$

From this expression and the definitions of $\tilde{x} = x - \bar{x}$ and $\tilde{z} = z - \bar{z}$, where the bars denote the means and E is the expectation operator, one can calculate the mean, M, and variance, V, of income for given futures and cropping plans:

$$(4) \qquad M = \bar{x}'A + \bar{z}'F + rB - rD;$$

$$(5) \quad V(A, F) = A'E(\tilde{x}\tilde{x}')A + F'E(\tilde{z}\tilde{z}')F + 2A'E(\tilde{x}\tilde{z}')F.$$

Equations (4) and (5) show that debt payments, rD, give any crop futures plan a lower mean for a given variance or, in common parlance, greater risk.

A point on the mean-variance frontier with variance, V^*, corresponding to mean, M^*, is computed by choosing A and F to minimize $V(A, F)$ subject to equations (1), (2), and (4). Letting λ shadow the land constraint, γ the

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[1] With a sympathetic banker who will lend money at close to prime (so that cost of the money is the prime rate less the rate on treasury bill posted as margin) and who will not impinge on the farmer's other credit lines, the cost of credit will be small. With a discount broker who will charge about $20 for a "round turn," the brokerage fees will be small.

[2] Peck considered using regression equations for prediction of futures mean-square error in her study of eggs. She credits Fried with the idea. In fact, she assumed the mean return of egg futures was zero, and she estimated the mean-squared error from the differences of a predicted and actual series.

credit constraint, and α the mean constraint, the Lagrangian for this problem is

$$L = -V(A, F) + \lambda(L - a'A) + \gamma(W - f'F - B) - \alpha(M^* - \bar{x}'A - \bar{z}'F - rB + rD).$$

The interesting Kuhn-Tucker conditions are[3]

(6) $L'_A = \alpha\bar{x}' - 2(A'E[\tilde{x}\tilde{x}'] + F'E[\tilde{z}\tilde{x}']) - a'\lambda \leq 0$, and $L_{A_i} \times A_i = 0$ for every i;

(7) $L'_F = \alpha\bar{z}' - 2(F'E[\tilde{z}\tilde{z}'] + A'E[\tilde{x}\tilde{z}']) - \gamma f' \leq 0$, and $L_{F_i} \times F_i = 0$ for every i;

(8) $L_B = \alpha r - \gamma \leq 0$ and $L_B \times B = 0$.

Noting that $A'\tilde{x} - F'\tilde{z}$ is the stochastic portion of income, $\tilde{Y}$, equation (6) states that either a crop is not grown or, at an optimal portfolio, its mean return times the rate of technical substitution of mean for variance, α, equals twice the covariance of the crops return with income, $\tilde{Y}$, and the shadow cost of land. Equation (7) has a similar interpretation. Both equations include the covariance of an activities return with the whole portfolio, so one needs to know the covariance of all the crops and futures, not just crops with their own futures.

The set of all efficient points makes up the mean-variance frontier. Any agent with a mean-variance utility function will select an (interior) point on the frontier at which his rate of commodity substitution of mean for variance equals the rate of technical substitution. These variances, covariances, and means are computed in the next section.

Means and Variances

An estimate of the means and variance-covariance matrix of the returns from crops and futures is required for the computation of the efficient set. This estimate is constructed (instead of by variate differencing) by applying Seemingly Unrelated Regression (SUR) technique (Thiel, p. 297) to a set of equations describing the quasi-rents of the crops and the returns from futures holdings (Fried). The SUR prediction error estimates the variances, $E\tilde{z}\tilde{z}'$, $E\tilde{z}\tilde{x}'$, and $E\tilde{x}\tilde{x}'$, while the SUR prediction estimates the means, $\bar{z}$ and $\bar{x}$, both conditional upon the opening futures prices and previous years' yields. This conditional mean-variance frontier describes the mean-variance trade-off with complete annual revision of the cropping pattern. This is not strictly true for Kern County because much of the cost of growing alfalfa is the establishment of stands that can last five years. Nevertheless, the conditional frontier is a better estimate of the choice set than the unconditional frontier which would be appropriate if all the crops had to be assigned the same acreages year after year. The remainder of this section reports the crop and futures equation.

Crop Equations

Because data on inputs are sparse and the cost data are often crude, crop quasi-rents were predicted from linear regression on a constant, expected cost and the product of expected yields and expected price. There is a futures price for cotton for the whole period and potatoes for half the period, so price expectations for these crops are taken as the futures price times a constant to account for backwardation. For the remainder of the period for potatoes and for beets and cottonseed, a lagged price times a constant to account for inflation is used. For alfalfa and barley, the wheat futures is used with a constant to account for the relation between wheat and the other crop price and for backwardation.[4] Thus, the regression coefficient on expected revenue contains both the effect of revenue on quasi-rent and the effect of backwardation, inflation, etc., on price expectations. A dummy variable was included in the potatoes regression to account for the two different estimates of price expectations.

Table 1 contains the definition of the variables and their sources. Preliminary investigation did not give the expected signs on the sugar beet equation so that the equation was split into separate cost and revenue equations. After estimation, this cost equation was subtracted from the revenue equation to provide an unbiased, if not efficient, estimate of π.

[3] The other Kuhn-Tucker conditions are the nonnegativity of B, A, F, λ, γ, and α; equations (1), (2), and (4); and complementary slackness.

[4] The problem with corn, which seems the more natural choice, is that it is harvested too early in the season to be well-timed with respect to the bulk of the alfalfa cutting or barley harvest. What it gains in closeness as an animal feed, it loses in timing. Note that B now contains the constant of proportionality.

Both the alfalfa and barley quasi-rent regressions gave good fits and correct signs:

$$\begin{array}{llll} \pi_{Alfalfa} = & 79.53 + & 7.63\, P^eY_F{}^e - & .72\, C^e, \\ & (15.36) & (0.94) & (0.09) \\ & (5.18) & (8.15) & (8.07) \end{array}$$

where $R^2 = .79$;

$$\begin{array}{llll} \pi_{Barley} = & 7.28 + & 12.80\, P^eY_F{}^e - & .54\, C^e, \\ & (37.23) & (2.49) & (0.44) \\ & (0.19) & (5.15) & (1.24) \end{array}$$

where $R^2 = .49$. In both cases, the t-ratios (first the standard errors and then t-ratios are reported in parentheses under the coefficients) for P^eY^e were quite high, indicating success in predicting barley and alfalfa prices from wheat futures, but the magnitudes of the coefficient are uninterpretable because they contain the conversion from wheat to other crop price. The lagged cost coefficients should be close to and above minus one because of the slight downward trend in real costs, but in these equations the cost coefficients are a little too high.

The cotton equation contains a variable for both predicted seed revenue $(P^eY^e{}_{L-Seed})$, based on a lag, and lint revenue, based on the futures price $(P^eY^e{}_{F-Lint})$.

$$\begin{array}{llll} \pi_{Cotton} = & 758.29 + & .95\, P^eY^e{}_{F-Lint} & \\ & (124.23) & (0.11) & \\ & (6.10) & (8.32) & \\ & & + 1.49\, P^eY^e{}_{L-Seed} & -3.66\, C^e, \\ & & (0.41) & (0.42) \\ & & (3.63) & (8.82) \end{array}$$

where $R^2 = .89$. Although all coefficients were of the right sign and significant, the expectation that the coefficient of $P_eY^e{}_{F-Lint}$ would be greater than one (a change in price would increase both yield and price and backwardation) was not borne out, and the coefficient on the cost variable was too low. Nevertheless, the high R^2 and t's make this a good equation for prediction purposes.

Root crops are widely believed to be risky, and the equations for sugar beets and potatoes bear this out with large prediction errors, low R^2, and a general lack of significance in the coefficients:

$$\begin{array}{llll} \pi_{Potatoes} = & 243.67 + & .46\, P^eY_F{}^e + & .23\, P^eY_L{}^e \\ & (761.41) & (0.12) & (0.18) \\ & (0.32) & (3.78) & (1.23) \\ & & + 573.97\, Dum - & 1.16\, C^e, \\ & & (310.27) & (1.10) \\ & & (1.85) & (1.05) \end{array}$$

Table 1. Definitions and Sources of Variables For Crop Quasi-Rent Equations

C	For each crop, deflated per acre variable costs from harvest and preharvest plus equipment and irrigation interest and depreciation, excluding charges for land. For alfalfa, ⅓ of the cost of stand establishment is included.
C^e	Previous year's cost.
R	Value of production divided by harvested acres, deflated.
π	$R - C$.
$P^eY_F{}^e$	Once-lagged, three-year moving average of yields per acre times a deflated futures price (for alfalfa and barley, 15 December price for September wheat; for cotton lint, 15 April price for December cotton; for potatoes, 15 January price for May potatoes only for 1969–1977).
$P^eY_L{}^e$	Once-lagged, three-year moving average of yields per acre times once-lagged deflated price received by farmers (for cotton seed, potatoes, and sugar beets).
DUM	A dummy variable. 1 for 1963–1968, 0 otherwise.

Sources: For revenues, yields, and prices, see Agricultural Commissioner; for costs, see University of California; and for the California CPI, which is the deflator, see California Governor.

where $R^2 = .25$;

$$\begin{array}{lll} R_{Sugar\ beets} = & 165.49 + & .51\, P^eY_L{}^e, \\ & (69.37) & (0.21) \\ & (2.39) & (2.50) \end{array}$$

where $R^2 = .23$;

$$\begin{array}{lll} C_{Sugar\ beets} = & 36.68 + & .83\, C^e, \\ & (28.48) & (0.13) \\ & (1.29) & (6.29) \end{array}$$

where $R^2 = .59$.

Futures

The futures strategies considered are those most appropriate to a grower: the sale or purchase at planting time of futures that mature slightly after harvest.[5] Provision is made for trading after a prespecified price change as a crude way of accounting for limited credit and for a mean-variance decision maker's disproportionate concern with large price swings. For both of these reasons, futures are imagined to be purchased with a stop-loss order varying between 4¢ and \$1.00 per unit (pound or bushel). For example, 50,000 pounds (one contract) of cotton sold with a 25¢ stop-loss amount (SLA) requires a \$12,500 line of

[5] If the decision process is viewed strictly as a one-decision point process, then the prices should all have the same date as the decision point.

credit. If the futures rises 25¢, the contract would be repurchased. These stop-loss orders allow the construction of complicated strategies that start speculative and end as hedges such as two long contracts with a 10¢ stop loss and one short contract. On a price rise, the position remains net one long; on a price fall, it reverts to one contract short (and a loss of 10¢ per pound times two contracts or $10,000 for cotton).

The mean and variance of holding futures were estimated by linear regression of futures gains on a constant and are reported in table 2. The Keynes-Hicks theory of backwardation with the "Cootner wrinkle" holds that during the period consumption comes from storage, the price of futures should rise, effecting a risk premium paid by storers to speculators. The regression results show this risk premium as an expected loss to the short position. The lack of significance (low t-ratios) was cited as evidence against the Keynes-Hicks-Cootner theory by Telser and others. In this formulation, high t-ratios would imply almost certain profits from holding a long position, so the low t-ratios are almost expected. Adding other variables, such as planting intentions or opening price, does not improve the predictive power of the equations.

Empirical Results

We used quadratic programming to construct the mean-variance frontier from the estimates of mean and variance constructed above and the opening futures prices for 1978. This section describes the cropping plans and futures holdings along this frontier. It gives two ways of choosing a point on the frontier and evaluates the effect of fixed debt on the optimal choice. It shows that the benefits of simultaneous choice of crops and futures are quite large and that the simultaneous choice has a large effect on the amount of hedging. Finally, it shows that the price of hedging is a significant determinant of the amount hedged and that forecasting can make a difference.

The Frontier

The mean-variance frontier starts with less risky and moves to more risky crops while going from hedge to speculative futures positions. The quadratic programming results show that at low mean returns (about $120 per acre), cotton and alfalfa are grown; about 16% of the cotton is hedged against a price drop of more than 25¢ per pound. Although barley is also a low-risk crop, it is omitted from the portfolio because it was projected to cause losses in 1978. Moving up the mean-variance frontier entails substituting sugar beets for the cotton and changing the futures position to a more speculative stance. In the data, going long in cotton has an expected positive return and a mean-variance trade-off somewhat comparable to growing sugar beets; so, by the time mean income reaches $200 per acre, the futures position is to speculate in cotton. The positions advocated in the sugar beet portion of the mean-variance frontier are suspect because of two peculiarities in the data: (a) the cost of growing sugar beets is suspect and

Table 2. Regression of Gains from Holding a Futures Contract on a Constant Term

Code	Commodity	Position	Stop-Loss Limit	Expected Return	Standard Error	t	R^2
			(1978 cents per pound or bushel)				
*SCOT*10	Cotton	Short	10	−2.13	10.81	0.200	0.003
*SCOT*25	Cotton	Short	25	−7.70	14.84	0.520	0.020
*SCOT*50	Cotton	Short	50	−9.13	16.78	0.540	0.020
*LCOT*10	Cotton	Long	10	10.08	14.65	0.690	0.040
*LCOT*25	Cotton	Long	25	3.19	17.15	0.190	0.003
*SPOT*4	Potatoes	Short	4	−0.90	1.77	0.510	0.020
*SPOT*10	Potatoes	Short	10	−0.41	1.43	0.290	0.006
*LPOT*4	Potatoes	Long	4	−0.60	1.60	0.380	0.010
*LPOT*10	Potatoes	Long	10	−0.47	1.47	0.320	0.008
*SWHT*25	Wheat	Short	25	−19.06	28.80	0.660	0.030
*SWHT*50	Wheat	Short	50	−6.26	43.78	0.140	0.002
*LWHT*25	Wheat	Long	25	−30.27	31.01	0.980	0.070
*LWHT*50	Wheat	Long	50	0.48	0.96	0.005	0.000

Source: Computed by Zellner's Seemingly Unrelated Regression Technique.

probably too low (Thor) and (*b*) the sample wheat futures and sugar beet profits have the large correlation of $-.5$, leading to the cross-hedging of sugar beets in the wheat market. Although it is hard to accept the recommendation that sugar beets be grown, a number of other crop combinations currently grown in Kern County could fill the expected high profit, mildly speculative niche: to name a few, carrots, garlic, soybean-barley double crop, tomatoes, and dry beans.

The further reaches of the mean-variance frontier are characterized by a potato-cropping system. Because early potatoes are a very risky, perishable fresh vegetable, very few operators (34 in the Bank of America sample of 1,028 cited by Pope) grow them, although these growers are each so large that potatoes are the largest acreage vegetable in Kern county. Potatoes are not hedgeable because the contracts traded are for Maine and Northwest potatoes and correlate almost not at all ($-.01$) with Kern potato profits. Moreover, the trade between mean and variance is so extreme at the point on the efficient set where potatoes are grown that outright speculating in cotton—up to the available credit limit—is part of the efficient portfolio.

Choosing a Point on the Frontier and the Effect of Debt

The evaluation of risk is the choice of a point on the mean-variance efficient set, either by a utility function written explicitly in mean and variance or by safety-first criteria. For instance, letting M be the mean and V be the variance, $\ln(M) - 100V/M^2$ is a mean-variance function. Figure 1 shows the tangency of a level curve of this mean-variance utility function to the mean-variance frontier at a mean of \$175,050. So, an agent with this mean-variance utility function would select the cropping and futures plans associated with a mean income of \$175,050. When the problem is altered to include a fixed debt load of \$80,000 (1,000 acres at the cheap price of \$1,000 per acre—80%—financed by a 10% mortgage), the optimal point on the frontier has mean \$370,000. Another way to view mean-variance frontiers is to convert the efficient set to a safety-first statement through

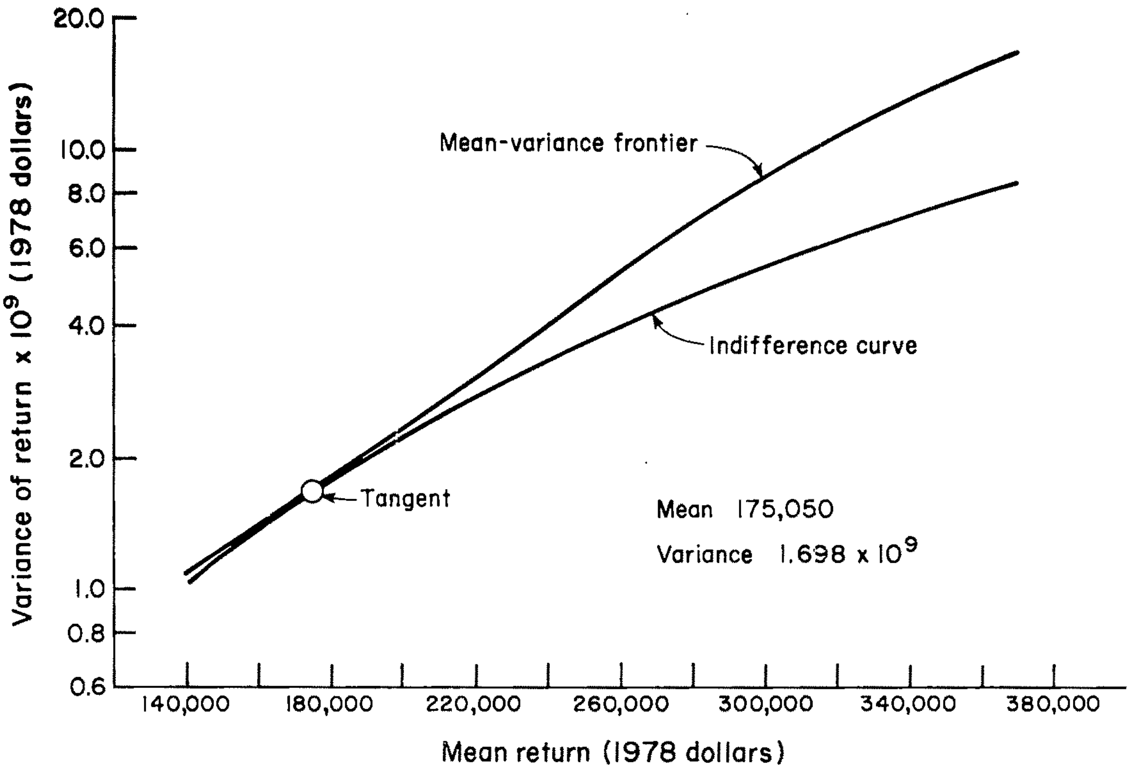


Figure 1. An indifference curve of a mean-variance utility function tangent to the mean-variance frontier

the Chebychev inequality, prob $(Y < M - k\sqrt{V}) < 1/k^2$, or a new variant (Berck and Hihn) of the inequality in terms of semivariance, SV, prob $(Y < M - k\sqrt{V}) < SV/(k^2V)$.[6] Using the semivariance Chebychev bounds, the probability of meeting a fixed payment of $80,000 increases as the mean return increases until the mean return is $233,000 and probability of success is 93%; it decreases thereafter. To break even (zero payment), the safest mean return is about $140,000. In these examples, which are two of many ways of selecting a mean-variance efficient point, fixed debt leads to the selection of riskier plans.

Benefits of Diversification

Table 3 shows that adding activities to the choice set substantially reduces the variance that must be incurred to achieve a given level of mean income. A comparison of the first two columns of the table shows that adding other crops (primarily sugar beets) to the alfalfa-cotton cropping system reduces the variance for a given mean by about one-third. For instance, at a mean income of $115,700, the cotton-alfalfa system's variance of income is 2.27×10^9, while the all-crops system's variance is only 1.44×10^9. Similarly, a comparison of the columns labeled "All Crops" with that labeled "All Crops and All Cotton Futures" shows that for all but extreme mean returns, the addition of both speculative and hedging possibilities in cotton futures does very little to improve the mean-variance trade-off. Finally, comparing the last two columns of the table shows that adding the other hedging and speculative possibilities—primarily wheat futures—again vastly decreases the variance for given mean. This final decrease in variance, however, is at least partially based on the high (and suspect) sample covariance between the profits from growing sugar beets and a short position in the wheat market. The appropriate conclusion is that both diversification of crops and the adoption of complicated hedging strategies significantly improve the mean-variance trade-off.

Effect of Diversification on Hedging

In addition to improving the mean-variance trade-off, the addition of activities to the choice set also changes the cotton-hedging strategy. The hedging strategy used by both Peck and Rolfo is based on the covariance of cotton and cotton futures. As shown in the first column of table 4, the strategy is to hedge 8.9% of the cotton crop for points of the efficient set corresponding to a low mean return and to decrease the hedge to zero for high mean-return points. Comparing the first column of the table to the second column (labeled Alfalfa, Cotton, and All Cotton Futures) shows the effects on the futures positions of allowing complicated hedging strategies with stop-loss orders and of including the covariance of the futures with alfalfa quasi-rents. The correlation with alfalfa increases the size of the hedge because the cotton hedge is negatively correlated with both cotton and alfalfa quasi-rents. The columns labeled "Initial" and "Deep Hedge" refer to the position taken on planting and the position taken when

[6] Let x have the cumulative distribution F with mean $\bar{x}$.

$$SV = \int_{-\infty}^{\bar{x}} (x - \bar{x})^2 dF.$$

Table 3. The Mean-Variance Frontier for Four Activity Choice Sets, Computed

Mean Return	Cotton and Alfalfa	All Crops	All Crops And All Cotton Futures	All Crops and All Futures
($ 1978)	-----(Variance in 1978 dollars^2 $\times$ 10^9)-----			
97,250	1.577	0.999	0.934	0.520
116,700	2.271	1.439	1.362	0.749
175,000	[a]	3.292	3.274	1.698
194,000		4.505	4.491	2.143
320,000		28.420	23.167	10.676

[a] This mean cannot be achieved.

Table 4. Percentage of Cotton Hedged by Mean Return For Three Sets of Activities, Computed

	Cotton and *SCOT50*	Alfalfa, Cotton, and All Cotton Futures		All Crops and All Futures	
Mean Return	Hedge	Initial Hedge[a]	Deep Hedge[b]	Initial Hedge[a]	Deep Hedge[b]
116,700	8.9	11.3	11.3	−8.4	6.1
155,000	8.9	−1.7	99.5	−8.4	6.1
175,000	1.4	−30.5	116.1	−10.4	3.3
194,000	[c]	−32.9	136.2	−12.6	5.4

Note: Negative signs indicate a long or speculative position.
[a] Position taken before any price changes.
[b] Position taken on 25¢ price drop.
[c] This mean cannot be achieved.

prices fall by 25¢, respectively. Futures positions that begin long but revert to a hedge on a large price fall allow speculation without the risk of large losses. When crops other than cotton and alfalfa and futures other than cotton are added to the crop mix, the last two columns of table 4 show the hedging strategy in cotton. Even at low mean returns, the initial position is now speculative, but the position after an adverse price fall is now only a mild hedge, less in fact than the Peck-Rolfo hedge. Apparently, other futures and other crops are more effective in diversifying the risk of the cotton-alfalfa system than are the cotton futures. Indeed, as this example shows, the choice of futures holding in a mean-variance framework is very sensitive to what activities other than own-crops and futures are included in the portfolio choice set.

Price of a Hedge

The price or "risk premium" of a hedge is the expected loss from selling the futures. A short position in cotton loses 9.3¢ per pound or about half of the per pound profits of growing cotton. The demand for hedging can be traced out by varying its price or risk premium and recording the consequent demand for hedging. In a $124,000 expected income plan in which only cotton and alfalfa are grown and the only future is the hedge SCOT50, a 1¢ change in the risk premium results in a 9/10% change in the percentage hedged. If the hedge were costless, the percentage hedged would double; but it would still be quite low. More complicated hedging strategies require a decrease in the profitability of the long position at the same time the "risk premium" of short position is decreased so that there are no certain profits from taking offsetting positions. Figure 2 shows the demand curves for hedging cotton in an all crops and futures activity choice set except LCOT10, SCOT10, and SCOT25. At an expected return of $155,600, the hedge more than doubles if the risk premium is eliminated, while at an expected return of $194,500 the ratio is closer to fifteen times. As these experiments show, the size of the risk premium has a large effect on the percentage of the crop hedged.

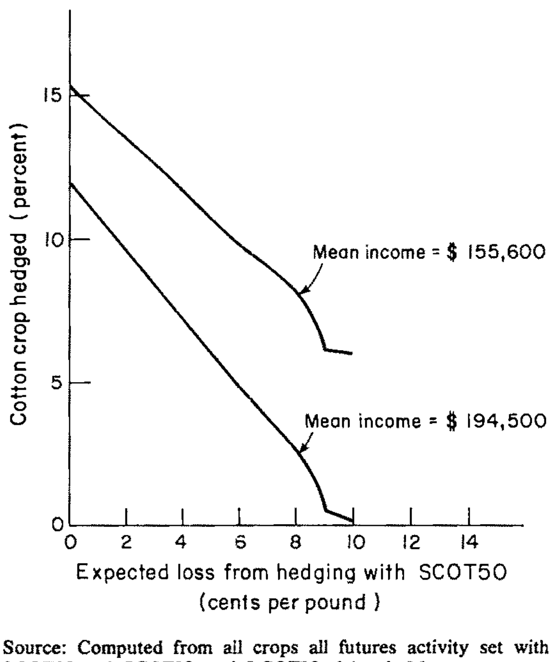
Forecast

This model does not do justice to forecasting because the futures price is used to forecast crop prices. A prediction of a smaller loss than the model predicts is a narrowing of the difference between the observed futures price and the expected price at the settlement time and is analogous to a prediction of a lower cash price than is predicted in the model. It leads to a greater hedge position (see fig. 2).

Conclusion

The empirical section verifies what the theory section postulates—that the costs of hedging and the opportunity to diversify risk by growing other crops substantially change the optimal hedge and opportunity set for California farmers. Although commodity exchanges want the additional hedging volume that could be generated by farmers, educating cotton farmers will not produce such additional volume: the price of hedging is high enough so that storers of cotton who have no yield risk find hedging worthwhile, but producers whose yield risk makes this insurance imperfect find the price too high.

Because this paper considers only a planting-time hedge, it leaves unsettled the optimal path for a hedge to take between planting



Source: Computed from all crops all futures activity set with SCOT25 and SCOT10 and LCOT10 deleted. Mean returns to LCOT25 were decreased by $.004 for each $.01 change in SCOT50.

Figure 2. Demand for hedging (percent hedge by expected loss per pound)

and harvest. At planting time, there is yield risk. As the crop year progresses, that risk is resolved until, at harvest, the producer has no yield risk. He is just the same as any other storer. It is reasonable that the hedge should evolve over the crop year from that appropriate to a producer to that appropriate for a storer. The mathematical tool for investigating the influence of new information on hedging is open-loop control which is well known. However, there is a twofold empirical problem: (*a*) constructing a yield prediction model that is updated as the crop progresses and (*b*) constructing a price prediction equation not wholly dependent upon the futures price. Such a model can point the way to the profitable use of futures by farmers.

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Empirical Analysis of Soviet Agricultural Production and Policy

Michael L. Wyzan

This paper employs production function analysis to examine a number of pivotal issues concerning the Soviet agricultural sector. Estimates of three input translog production functions for five agricultural commodities grown in the Soviet Union from 1960–76 are reported. These results are used to draw inferences on such matters as the rationality of Soviet agricultural factor pricing, the nature of agricultural returns to scale in the USSR, and the scope of factor substitution in that country. The empirical evidence suggests that Soviet decisions in the sphere of agricultural production, contrary to the conventional wisdom, are well-founded technologically.

Key words: kolkhoz, New Lands Program, partial elasticity of substitution, pooled cross-section time-series data, returns to scale, Soviet Union, *sovkhoz,* specification error.

The estimation of production functions is in many instances a powerful tool for examining important matters of economic policy. In this paper, three input translog production functions are estimated for five Soviet agricultural commodities. The estimation is performed on a data set gathered by the author from official Soviet statistical publications. The data contain information on output, land, labor, and capital, measured in physical units, covering grain, sugar beets, cotton, potatoes, and vegetables grown in the Soviet Union during the seventeen-year period, 1960–1976.

The results are used to draw inferences concerning various important aspects of Soviet agricultural policy. Although outputs are derived from inputs within a great variety of institutional structures (Western market orientation, Soviet command mechanisms, Yugoslav self-management, and so on), all such schema are ultimately constrained by the physical technology of production.

Accordingly, the rationality of Soviet factor pricing can be examined by looking at productive relationships in purely physical terms. Because the idiosyncracies of Soviet factor pricing always result in prices which are "too low," we would expect certain factors to be relatively "overused." Hence, it might be asserted that the more the pricing of an input deviates from neoclassical input pricing, the likelier it is that its marginal product will be insignificantly different from zero. Evidence relative to this hypothesis is presented below.

As a second example of the relationship between productive technology and economic policy, we might consider returns to scale. It has been common in the literature on Soviet agriculture to assume that the Soviet penchant for large farms is unjustified on technological grounds; that is, that returns to scale in agriculture are generally rather small (Bradley and Clark). Yet evidence as to the actual magnitude of scale effects has rarely been presented; such evidence is reported in this paper.

Results also are presented concerning the nature of factor substitution in Soviet agriculture. Previous work on Soviet productive technology has indicated that factor substitution in the Soviet industrial sector is quite limited (Weitzman). Our findings for the agricultural sector are interesting not only in comparison with these results, but also because they have important implications for evaluating certain specific Soviet policies. These include the New Lands Program of the Khrushchev era and the impact of the intro-

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duction of new vintages of equipment on factor productivity.

The paper is organized as follows. The first section is a discussion of the data set and some related econometric matters. The second briefly describes the properties of the translog production function. The third section presents the results and outlines their implications for a variety of policy issues, and the last provides some concluding remarks.

Data and Econometric Considerations

Because the data set was gathered by the author, innumerable matters concerning its format and peculiarities might be mentioned. Considerations of space preclude all but the most cursory description thereof. The data were obtained at the Foreign Demographic Analysis Division (FDAD) of the U.S. Department of Commerce. FDAD maintains an outstanding collection of official Soviet statistical publications on the Soviet Union and Eastern Europe, without which empirical work on this vital geographical area would be quite difficult.

As mentioned in the introduction, figures are available for five crops, grain, sugar beets, cotton, potatoes, and vegetables. Other crops (especially sunflowers, flax, and fodder crops) and livestock products are not included because there are no published data on labor inputs into their production. The data on each crop are in the form of a pool of cross-sectional and time-series observations, with each time-series covering some fraction of (and in some cases, all of) the period, 1960–1975. The cross-sections are formed by union republics (of which there are fifteen) and sometimes also by types of enterprise (collective farm or state farm) within republics. Because of the uneven availability of the requisite figures, the time-series are of varying lengths, ranging from a full seventeen years for grain in the Russian republic to seven years for cotton in Turkmenistan. In total, there are 999 cases, 323 for grain, 199 for sugar beets, 101 for cotton, 229 for potatoes, and 147 for vegetables.[1]

All data come directly from official Soviet statistical publications, either national or republican, and are not qualitatively adjusted (the most recent national publication is *Tsentral'noe Statisticheskoe Upravlenie*). For output and all inputs, the figures are broken down by crop, year, republic, and, generally, type of farm. Land is measured in thousands of hectares of "sown area," defined as the productive area in the spring, as recorded at the end of the spring sowing. A word is in order on variation in land quality across republics, a phenomenon expected to be quite important in such a large country. It was stated above that none of the data is qualitatively adjusted. Two pieces of evidence may be cited in support of our decision not to adjust the land data. First, regional dummy variables included in estimated (translog) production functions all prove to be statistically insignificant for every crop. Second, Clayton (p. 453) reports that her own qualitatively adjusted Soviet land data, when employed in an aggregative production function, give insignificantly different results from unadjusted data in that function.

Labor inputs are measured in thousands of man-hours, similarly broken down. The statistical publications provide these numbers as labor intensity data—man-hours per unit of output. Data on labor inputs are easily obtained by multiplying the intensity figures by an appropriate physical weight measure of output. Output figures are available in thousands of metric tons.

Capital services are measured by proxy. No crop-specific Soviet capital data are available or have even been suggested by previous studies. In work in other areas, electricity usage has served as a proxy for capital, under the (plausible) assumption that the flow of capital services is in roughly fixed proportion to the use of electricity in a given time period (Moody). In this study, because electricity data, broken down by crop, are unavailable, the number of a certain type of machine in existence in each year serves as the proxy. Grain combines serve this purpose in grain cases, cotton machines in cotton cases, and tractors in all other cases. A good argument can be made for machine numbers being a reasonable proxy for the entire input of capital into the production of the respective crops.[2]

[1] An appendix detailing the data-gathering process is available upon request from the author. See Wyzan, chap. 2, on which this discussion is based. The crop categories sugar beets, cotton, and potatoes are homogenous; "grain" consists primarily of wheat, barley, oats, rye, corn, pulses, millet, rice, and buckwheat. "Vegetables" are composed mostly of cabbages, tomatoes, cucumbers, onions, carrots, and beets.

[2] Tractors are used in vegetable cases because there seems to be no piece of capital equipment specific to their production. Although some figures are available on beet combines and potato combines, such data cannot be obtained for all cases. In the

Before moving on, two econometric matters deserve mention. The first comes under the general heading of specification error, and, more specifically, the measurement of capital by proxy and the omission of some important inputs, such as fertilizer, irrigation, and seed. The second concerns the fact that the data set is what might be called an "unmatched" pool of cross-sectional and time-series observations.

In the following discussion, it is assumed that we are dealing with a log-linear functional form, such as the Cobb-Douglas or translog function. The specification problem may be summarized by noting that instead of having available the correct Txk matrix of observations on k independent variables, X, we have Z. The latter is a matrix differing from X either in dimension, if there are observations on fewer than k regressors, or in the numbers in one of its columns, if one of the regressors is measured by proxy (among other reasons), or both. It is well-known that the estimated coefficients of the z's are biased and inconsistent estimators of the true coefficients of the x's (Griliches).

Let M be the proxy related to the true measure of capital services, K, by

$$M = K\theta + \mathbf{e}, \tag{1}$$

where θ is a fixed but unknown parameter and $\mathbf{e}$ is a vector of well-behaved disturbance terms. As just noted, the use of M biases the estimates of the output elasticities of all the inputs. However, it has been shown that the asymptotic bias to our estimates of the output elasticities of land and labor caused by using M is less than that caused by not having any measure of K at all, under most circumstances. These circumstances include whenever land and labor are measured without error, as well as cases in which they are inaccurately measured, but the output elasticity of capital is not "close" to zero (Barnow, Aigner). Because we have reason to believe that our land and labor data are relatively accurate, and because the conventional wisdom on proxy variables is to include one when you have it, we seem to be on firm ground in our use of a proxy.

We turn next to the question of missing independent variables. If there is just one omitted variable, say, fertilizer, the bias to the estimated output elasticity of each input is the product of two numbers. The first is the regression coefficient on that input which would result if fertilizer were used as the dependent variable in an "auxiliary" regression on the other three inputs. The second is the output elasticity of fertilizer in the correctly specified production function.

If we are safe in assuming a positive output elasticity for fertilizer, the correlation between a particular input and fertilizer inputs determines the sign of the bias to the estimate of the output elasticity of that included input. In a time-series data set, of course, correlations between independent variables depend upon whether the given variables are growing, declining, or remaining unchanged. In this particular data set, land inputs remain fairly unchanged over the period, labor inputs decline at about 2% annually, and capital inputs rise at approximately 5½% per year. Deliveries of fertilizer grew at a fairly rapid rate. We therefore expect the output elasticity of capital to be overestimated, that of labor to be underestimated, and little bias to the estimated output elasticity of land.

Fortunately, we do have some evidence to corroborate these conjectures. All of the production functions reported below were estimated with and without a time index denoting neutral technical progress. The inclusion of such a term should take account of some of the effects of excluded inputs, the applications of which have been growing over time. In fact, the notion of technical progress may be merely a convenient way to capture the effects of the absence of some inputs and the mismeasurement of others (Griliches and Jorgenson). Evidence reported below is highly supportive of these assertions.

A word is also in order on the status of the data set as a pool of cross-sectional and time-series observations. As noted above, the data set on each crop consists of a group of concatenated time series of varying lengths. Each series consists of observations on a particular republic and covers a period which varies in length from seven to seventeen years. For nine of the fifteen republics, there are two such series, one for collective farms and one for state farms.

Ideally, one would employ the seemingly unrelated regressions technique, with each republic as a separate equation, and use the results to test whether or nor pooling the data is statistically justified. If it is decided to pool the

absence of the knowledge of an equivalency factor between tractors and the relevant type of combine, it was deemed best to use tractors everywhere.

data, further statistical means can be used to take into account various disturbance structures. Unfortunately, the usual methods of doing this are unavailable when the time series are of different lengths (Zellner).[3] In the end, therefore, the entire group of observations on a crop, with no account taken of the particular year, republic, or type of farm which a particular observation represents, is used in the estimation of the production function for that crop.

The Translog Production Function

The three-factor translog production function employed in this study is written,

$$\begin{aligned}(2)\quad \ln y_i = {} & b_0 + b_1\ln R_i + b_2\ln L_i + b_3\ln K_i \\ & + b_4(\ln R_i)^2 + b_5(\ln L_i) + b_6(\ln K_i)^2 \\ & + b_7(\ln R_i)(\ln L_i) + b_8(\ln R_i)(\ln K_i) \\ & + b_9(\ln L_i)(\ln K_i) + \epsilon_i,\end{aligned}$$

where the subscript i indexes a particular observation, y is output, R is land, L is labor, K is capital, and ϵ, the vector of disturbances, satisfies the usual conditions (Berndt and Christensen). Results using the Cobb-Douglas, constant-partial-elasticity-of-substitution, and transcendental production functions are contained in Wyzan, appendix 2.

Although it also can be viewed as an exact representation of the productive technology, the translog function is best seen as a second-order Taylor series expansion around the means of output and of each input. It is chosen because it allows the researcher to estimate the nature of returns to scale and factor substitution, instead of imposing a priori restrictions on them. Furthermore, regions with nonconvex isoquants (noneconomic regions) exist whenever any coefficient b_i $(i=4, \ldots, 9)$ is estimated to be significantly different from zero. (If none is, the function reduces to the Cobb-Douglas form.) Finally, neutral technical progress is easily taken into account by letting

$$(3)\qquad y = e^{\lambda t}h(R,L,K),$$

where

$$h = e^{b_0}R^{(b_1+b_4\ln R+b_7\ln L+b_8\ln K)}L^{(b_2+b_5\ln L+b_9\ln K)}K^{(b_3+b_6\ln K)},$$

and t is a time index equal to 1 for the first year of the data set, 2 in the second year, and so on. We can therefore estimate

$$(4)\qquad \ln y = \lambda t + \ln h.^4$$

Results and Analysis

We turn now to the presentation and analysis of the empirical findings. In table 1, the coefficients of the translog production functions estimated for each crop without a technical progress term are presented. In table 2, similar results are reported for each crop, in this case with neutral technical progress taken into account. Table 3 reports the estimates of returns to scale and of each of the partial elasticities of substitution. σ_{ij} refers to the partial elasticity of substitution between inputs i and j $(i,j = R,L,K, i \neq j)$. The figures refer to the mean values of these effects, found by first evaluating the relevant effect at every point in the data set on a crop, and then determining the arithmetic mean of these calculations. These elasticities are of the Allen-Uzawa variety and are calculated according to a formula given by Berndt and Christensen (p. 97).

The estimates shed light on a number of interesting policy questions. Before exploring these areas, a couple of technical matters deserve mention. First, recall that if none of the coefficients $b_4, \ldots b_9$, is estimated to be significantly different from zero, the translog function reverts to the Cobb-Douglas function. Note from table 2 that, for grain and sugar beets, (when technical progress is included), none of these coefficients is significant. In the cases of the other three crops, at least one such coefficient is significant. This may be taken as evidence that the translog function is not always (for all crops) superior to the Cobb-Douglas function. One must keep in mind, however, that multicollinearity undoubtedly has raised the standard errors of the coefficient estimates. For this reason, in addition to the numerous advantages cited above, the translog function remains our preferred functional form.

Second, it is useful to compare the estimated coefficients on the logarithms of land, labor, and capital for each crop between the

[3] Actually, Schmidt has shown that it is possible to get satisfactory results by ignoring the "extra" observations when estimating the covariance matrix. The vastly divergent lengths of the time series within our data set precluded using this result, however.

[4] Some problems with the translog function include the possible existence of multicollinearity among the regressors, specification error caused by the fact that it is only a second-order approximation, and the fact that, like any Taylor series expansion around a point, it may be a poor approximation to the true function far from that point.

Table 1. Translog Results without Technical Progress

Crop	Intercept	Land	Labor	Capital	Land²	Labor²	Capital²	Land*Labor	Land*Capital	Labor*Capital	R^2
	Coefficients of										
Grain	−.033*[a]	.596**[a]	−.069	.697**	.514	.019	.227**	.084	−.845**	.296	.619
	(−2.27)[b]	(5.64)	(−1.39)	(11.71)	(1.29)	(.157)	(2.87)	(.185)	(−.265)	(1.68)	
Sugar beets	−.015	.121	.684**	.753**	−.366	.137	.265	−.091	.237	−.464	.578
	(−.705)	(1.04)	(7.21)	(9.07)	(−.937)	(.425)	(1.62)	(−.144)	(.620)	(−1.27)	
Cotton	.026*	.938**	.307**	.062	−.683	−1.355*	−.264**	1.531	.550	.232	.907
	(2.07)	(6.78)	(2.66)	(1.21)	(−.81)	(−1.96)	(−3.7)	(1.07)	(1.82)	(.89)	
Potatoes	−.014	.002	.702**	.810**	−.267	−.066	.365**	.258	−.207	−.181	.796
	(−.889)	(.023)	(8.92)	(13.03)	(−1.28)	(−.403)	(2.91)	(.800)	(−.615)	(−.703)	
Vegetables	−.054**	.006	.869**	1.006**	.363	.401*	.734**	−.685	−.420	.268	.720
	(−2.84)	(.052)	(10.18)	(9.61)	(.927)	(2.09)	(3.77)	(−1.58)	(−.861)	(.585)	

Note: The heading of each column refers to the logarithm of the relevant variable, with, for example, $(Capital)^2$ denoting the coefficient on the square of the log of capital, and (*Land*Labor*) denoting the coefficient on the product of the logs of land and labor, and so on.
[a] Two asterisks mean that the regressor is significant at .01; one means that it is significant at .05.
[b] t-statistics are in parentheses below each estimated coefficient.

Table 2. Translog Results with Technical Progress

Crop	Intercept	Land	Labor	Capital	Land²	Labor²	Capital²	Land*Labor	Land*Capital	Labor*Capital	λ^c	R^2
	Coefficients of											
Grain	−.257**[a]	.616**	.040	.419**	.162	.068	.062	.276	−.522	.158	.024**	.663
	(−6.81)[b]	(6.18)	(.794)	(5.89)	(.427)	(.591)	(.782)	(.644)	(−1.71)	(.944)	(6.37)	
Sugar beets	−.493**	−.035	.902**	.013	−.214	.214	−.240	−.103	.466	−.353	.053**	.690
	(−.810)	(.343)	(10.51)	(.110)	(−.638)	(.772)	(−1.56)	(−.191)	(1.72)	(−1.13)	(8.23)	
Cotton	−.185**	.765**	293**	.001	−1.191	−1.628**	−1.47*[a]	2.610[b]	.406	−.078	.019**	.944
	(−6.34)	(6.92)	(3.23)	(.029)	(−1.80)	(−3.00)	(−2.54)	(2.32)	(1.72)	(−.370)	(7.66)	
Potatoes	−.176**	−.024	.791**	.563**	−.239	−.062	.287*	.272	−.458	−.025	.017**	.802
	(−2.82)	(−.247)	(9.37)	(5.10)	(−1.16)	(−.038)	(2.25)	(.858)	(−1.33)	(−.094)	(2.68)	
Vegetables	−.319**	−.051	.958**	.525**	.422	.381*	.519*	−.486	−.476	.190	.026**	.738
	(−3.57)	(−.458)	(10.89)	(2.78)	(1.11)	(2.04)	(2.26)	(−1.14)	(−1.00)	(.427)	(3.03)	

Note: The heading of each column refers to the logarithm of the relevant variable, with, for example, $(Capital)^2$ denoting the coefficient on the square of the log of capital, and (*Land*Labor*) denoting the coefficient on the product of the logs of land and labor, and so on.
[a] Two asterisks mean that the regressor is significant at .01; one means that it is significant at .05.
[b] t-statistics are in parentheses below each estimated coefficient.
[c] λ is the coefficient on the time index t.

(sugar beets, potatoes, and vegetables) have negative elasticities of land—an impossible result when an optimizing land purchaser faces positive rents but quite possible here. Farms are so large and generally grow such a variety of crops that land inputs to a particular crop can increase considerably and, perhaps, inordinately. This may well have happened for these three, not usually land-intensive, crops.

Capital pricing is a complex matter, intermediate in "rationality" between labor and land pricing. The extension of credit to farms has grown in recent years, and physical capital services are a component (if an arbitrarily calculated one) of cost (Morozov, pp. 99–101). In our results, capital has a positive elasticity for all crops, but an insignificant one for sugar beets and cotton. This intermediate finding for capital correlates well with the intermediate rationality of capital pricing. In sum, our hypothesis seems to be well-founded.

Another interesting matter is the question of the estimated mean returns to scale, as reported in the first column of table 3. They are surprisingly large, being greater than one for all crops but sugar beets. In fact, the crops exhibiting the largest scale effects are vegetables and potatoes, two commodities not generally thought to be characterized at all by increasing returns.

Our data set, being essentially an aggregative (over farms) time series, is less than ideal for measuring returns to scale. Care must be taken in interpreting these results, because larger input vectors may only mean a larger republic (in a cross-sectional context) or growth due to addition of new farms (in a time-series context). Even so, estimating scale parameters from aggregative data sets is hardly unusual in economics. These results are interesting, especially in view of the assertion of Bradley and Clark that, despite Soviet attempts to do so, farms cannot be run efficiently on large scales imitative of industrial enterprises. They cite as evidence several factors, all of which center on the difficulty of supervising a large labor force in an agricultural setting. These include the sequential nature of production, the fact that the results of work in the planting stage cannot be observed until several months later when it is difficult to determine responsibility for failure, and the physical dispersion of tasks. Our finding of high estimated returns to scale in Soviet agricultural production must be taken as evidence against the Bradley-Clark hypothesis.

The next topic is the mean estimated partial elasticities of substitution ("substitution elasticities"), presented in table 3. These estimates, as is well-known, have major implications for the potential growth of the output of the crop to which they apply. Since the weight of each input in the (percentage) growth rate of output is its output elasticity, it is of interest to know what happens to these output elasticities as relative factor intensities change, knowledge derivable from the partial elasticities of substitution.

If the partial elasticity of substitution between any two factors is between zero and one, the size of the output elasticity of the faster-growing factor relative to that of the other factor decreases. The opposite pattern of change occurs under two circumstances. It happens when the partial elasticity of substitution between two inputs exceeds one; in this case, the relative increase in the usage of the faster-growing factor is larger than the relative decrease in its marginal productivity. It also occurs when the partial elasticity of substitution is negative (the factors are complements). Here, the relative marginal productivity of the faster-growing factor actually increases with its relative usage.

Weitzman (and others) have found in two-input studies that a low (positive) elasticity of substitution between labor and capital exists for the Soviet industrial sector (Weitzman). When this result is combined with the fact that capital inputs are growing rapidly while labor inputs are (at best) stagnant, a relative decline in the output elasticity of capital is implied. Hence, capital's contribution to output growth shrinks as production becomes more capital-intensive; while labor's weight rises, future growth of labor resources is unlikely under present Soviet demographic conditions. All of this bodes ill for future industrial output growth.

Can similar results be found for the agricultural sector? We know that capital inputs to this sector have been rising fairly rapidly, labor inputs declining slowly, and land inputs have been fairly unchanged. Note from table 3 that twelve of the fifteen substitution elasticities are either greater than one or less than zero. Because such elasticities imply a rising output elasticity for the faster-growing factor, the prognosis for future Soviet agricultural output growth seems quite favorable.

The substitution elasticities reported above tell us that the output elasticity of capital, for

all crops but sugar beets, is expected to rise relative to both land's and labor's. For grain and potatoes, a further boost to output growth occurs because land's output elasticity is rising relative to labor's. As it turns out, an optimistic prognosis for the growth of output exists for all crops except sugar beets, where low positive mean σ_{LK} and σ_{RL} signal the ascendancy of labor's output elasticity relative to those of the other two inputs. This generally favorable forecast is more than a little surprising.

A number of other observations might be made concerning the substitution elasticities. The high substitution elasticity between land and labor in grain production is especially interesting in the light of the New Lands Program of the Khrushchev era. This program was characterized by the sowing to grain of immense tracts of previously uncultivated land in Kazakhstan (Central Asia). It permanently changed the regional distribution of Soviet grain production, as evidenced by the fact that, in 1979, the grain harvest in Kazakhstan, for the first time ever, exceeded that of the Ukraine, the traditional Soviet "breadbasket."

The New Lands Program may be seen, in part, as the substitution of plentiful Central Asian land for scarce labor. It also was an attempt to increase production in areas where labor is more plentiful than in the European USSR (of which Kazakhstan is an example). As Gustafson has noted, "Khrushchev in his memoirs claimed that he too favored intensification [that is, a program of raising yields in the European USSR as opposed to opening up new lands elsewhere], but that the country lacked the necessary supporting industrial base . . . and *skilled manpower*" (p. 48). Our finding of a high substitution elasticity between land and labor in grain production demonstrates that this program was based on sound technological grounds. This is another surprisingly favorable empirical finding.

Finally, one might speculate about why the output elasticity of capital, for all crops but sugar beets, has remained significantly positive even as capital intensity has risen. The successive replacement of each vintage of capital equipment (e.g., tractors) with an improved version may help to explain this occurrence. Relative to the Tenth Five-Year Plan (1976–1980), Carey has observed,

> The retirement rate for tractors dropped sharply in 1975. Lower retirement rates would allow faster-than-normal expansion of [machine] parks despite the slower growth of deliveries. Also the trend to larger tractors with greater horsepower and the recent introduction of new combine models will allow parks to be qualitatively improved. (p. 592)

Continuous improvement in the qualitative aspects of capital equipment may account, at least in part, for the presence of a high marginal product of capital for virtually every crop.

Conclusions

In this paper, estimates of production functions for five Soviet agricultural commodities have been presented. Some evidence on technical questions, such as the possibility of using a technological change term to unbias coefficient estimates, has been presented. More important, empirical evidence has been reported on a number of pivotal questions of Soviet agricultral policy. In general, our findings are surprisingly supportive of the appropriateness of Soviet decisions; large farms do seem to be more efficient, land-labor substitution is possible, and the outlook for output growth is good for most crops. This is true despite strong evidence of microeconomic irrationality in Soviet factor pricing.

The last several years have been poor ones for Soviet agriculture, especially for grain (where there were very small harvests in 1977, 1979, and 1980), and sugar beets (which have been disappointing in every year since 1977). The findings of this paper suggest the following (tentative) conclusion: Whatever accounts for the dismal performance record of Soviet agriculture, its problems do not seem to be endemic to the technology of production.

The search for an explanation must lead elsewhere, perhaps to that illusive and uncontrollable, but extremely important, productive input, the weather. Meterological factors, subsumed in the normally distributed disturbance term, may very well account for the extreme annual variation in Soviet crop (especially grain) production. If so, and if, as suggested by the results of this paper, there are no obvious technological limitations which would make Soviet institutional choices inappropriate, then a major reappraisal of Western conventional wisdom on this subject is surely in order.

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Multiattribute Utility Analysis: The Case of Filipino Rice Policy

Gordon C. Rausser and Joseph Yassour

Major uncertainties and conflicting objectives often arise in public-policy analysis. This paper advances a framework that is appropriate for public policy problems frequently encountered in agriculture and food systems. Among other possible benefits, its principal value is to provide focus on the major conflicts, trade-offs, and subjective perceptions among affected groups. It can be used to isolate major disagreements, needed empirical evidence, appropriate degrees of risk aversion, equity value judgments, and consensus solutions. In an empirical setting, the framework is used to evaluate price policy for rice in the Philippines.

Key words: multiattribute utility analysis, Philippine rice system, public policy, risk aversion.

Agricultural public agencies generally are charged with the responsibility for meeting the needs and desires of different groups. These groups include producers, consumers, the government, suppliers of inputs, intermediaries (assemblers and distributors), and landowners. Hence, it is not surprising that these agencies have more than a single objective by which to evaluate their effectiveness. The evaluation of trade-offs among the resulting multiple objectives is confounded by major uncertainties found in most agricultural commodity systems. Weather conditions, pests, and diseases introduce significant yield variability. Frequently, low demand and supply elasticities compound the effect of such variability on market price uncertainties.

The purpose of this paper is to demonstrate empirically how a stochastic, multiple-objective, decision-making framework can be operationally useful for public agencies. The first part of the paper describes the general model for optimization under uncertainty and multiple objectives. This model is then applied to determine the optimal price policy for rice in the Philippines.

Model and Methodology

The paradigm for decision making under uncertainty and multiple objectives has been referred to as multiattribute decision analysis (Keeney and Raiffa). This approach consists of two major components: the decision tree and the objective function. Decision trees are flow diagrams which illustrate problems as a chronological arrangement of choices that are controlled by the decision maker and those determined by chance (Raiffa). The probability distributions assigned to chance events can be based on historical data, regression analysis, econometric modeling, or—as often happens—the subjective perceptions of the decision maker.

The most difficult task in multiattribute decision analysis is to determine the appropriate objective function. The least restrictive objective function is the expectation of the multiattribute utility function (MUF):

$$(1) \qquad Eu(x_1, x_2, \ldots, x_n).$$

The construction of such a function involves the following steps: (*a*) prepare a list of objectives (*b*) select a performance measure or attribute for each objective; (*c*) determine

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whether special independence relationships hold among the performance measures allowing simplification of the MUF; (*d*) assess—if such independence relationships hold—the univariate utility function for each performance measure, $u_i(x_i)$; (*e*) determine the scaling constants (weights) of the univariate utility function in the multivariate objective function; and, finally, (*f*) compute the expected utility.

It is crucial to identify clearly the major objectives of the agency in question. Most often, objectives are vaguely identified. The most common objectives of agricultural public agencies are (*a*) increased income of farmers, (*b*) increased welfare of consumers, (*c*) self-sufficiency, (*d*) price stability, (*e*) improvement in the balance of payments, (*f*) decreased operational expenditures, and (*g*) stable flow of supply.

The performance measure or attribute associated with each objective must be quantified. The measures should be simple and meaningful to the users of the model. This is particularly important because the users must provide utility functions for each of the attributes, independence relationships, and weights for the MUF. Because this task is sufficiently complicated with simple performance measures, overly sophisticated or theoretical measures should be avoided. The construction of the objective function relies heavily on the preference structure and thus the degree of risk aversion of the decision maker. It requires a thorough interviewing process.

If independence exists among the performance measures, then such relationships can be used to specify the appropriate form of the MUF. For simplicity, analysts often assume additive independence relationships. However, other independence relationships can exist and can be used as a basis for more general forms of the MUF. Three types of independence relationships are examined: preferential independence, utility independence, and additive independence. The form of the objective function depends on whether all or some of these relationships exist. In what follows, each type of independence will be defined and its implications for the form of the objective function will be drawn.

The set of attributes A is preferentially independent of set B if preferences over set A do not depend on the amounts in B. Preferential independence is not reflexive. Set A is utility independent of set B if preferences over lotteries on (a, b') do not depend on the fixed amount of b'. Utility independence is not reflexive. The set of attributes A and B are additively independent if preferences over lotteries (a, b) depend only on the marginal probability distributions of a and b and not on their joint distributions.

It has been shown by Fishburn and by Keeney that, if additive independence holds among all attributes, the MUF is of the form,

$$u(x) = \Sigma_i k_i u_i(x_i) \tag{2}$$

(additive). If, however, preferential independence and utility independence hold but additive independence does not, the MUF has been shown by Keeney to be of the form,

$$1 + ku(x) = \Pi_i[1 + kk_i u_i(x_i)] \tag{3}$$

(multiplicative), where k_i is the scaling constant for utility function, u_i, and k is the aggregate scaling constant.

If the objective function is separable—additive or multiplicative—the researcher evaluates the risk perception of the decision maker for each of the attributes, i.e., univariate utility functions are assessed. A five-point utility function may be constructed using 50–50 lotteries.[1] The general form of the function (risk-neutral, constant risk-averse, decreasing risk-averse, etc.) also is determined. Using the general form of the utility function and the five-point utilities, a continuous utility function is approximated.

After the independence relationships and the form of the multiattribute utility function are known, the researcher determines the scaling constants or weights of the attributes. These constants are represented by the k and k_i's in equations (2) and (3).

The Case of the Filipino Rice Industry

The agency charged with the responsibility for formulating and implementing rice policy in the Philippines is the National Grains Authority (NGA). In general, the NGA attempts to promote the integrated growth and development of the Filipino rice industry. Specifically, Presidential Decree No. 4 states:

[1] For a good description of the 50-50 lotteries procedure, see Anderson, Dillon, and Hardaker (pp. 70–75). This approach captures the certainty equivalent for a specified lottery by determining the point of indifference between a risky prospect and a sure prospect. The difference between the certainty equivalent and the expected monetary value is the risk premium which is a function of decision maker degree of risk aversion.

NGA shall devise a system by which it can insure the adequacy of supply and stability of consumer prices at levels within the reach of the low-income families while maintaining the announced floor price to assure farmers or producers with a fair return on their investment. The rationale behind this is the fact that grain is a major item in the food basket of Filipino families. Thus, it has a pervasive effect on Philippine society such that the slightest imbalance in its supply and price is felt nationwide.

Five objectives were chosen to represent the rice welfare of the Philippines for the NGA: (*a*) increase rice farmers' net income, (*b*) attain self-sufficiency in rice production, (*c*) increase consumers' welfare, (*d*) stabilize the market price of rice, and (*e*) decrease government expenditures. The selection of these objectives was based on interviews with officials of the NGA. Similar objectives are reported in Barker, Apiraksirikul and Barker, Mangahas, Herdt and Lacsina, and Timmer.

The performance measure for farmers' net income is the average net income of a rice farm in one cycle (wet).[2] The net income was defined as the gross income (sales) minus the variable cost (hired labor and inputs):

$$(4)\quad x_1 = \frac{\sum_{j=1}^{2} M_j[(Y_j h - H_c - H_s)\bar{P}_p - h(\bar{C}L_j + \bar{C}I_j)]}{\sum_{j=1}^{2} M_j},$$

where x_1 is average net income to farmer per cycle (pesos), M_j is number of farms in category j, j is 1 for irrigated farms and 2 for nonirrigated farms, Y_j is yield per hectare in farm of type j (kilograms per hectare), h is average farm size (2.5 hectares), H_c is farm household consumption per cycle (535 kilograms of palay [paddy rice]), H_s is farm household storage in the wet cycle (135 kilograms of palay), $\bar{P}_p$ is the price of palay to the farmer (pesos per kilogram), $\bar{C}L_j$ is cost of hired labor in farm type j (pesos per hectare), and $\bar{C}I_j$ is cost of inputs in farm type j (pesos per hectare). The net income of farmers is defined as the income above the subsistence level. Household consumption and household storage consumed during the dry cycle were subtracted from wet cycle production.

The performance measure for self-sufficiency in rice production is the percentage of the quantity supplied out of the quantity needed to meet the average consumption of the nonrice-farming population (100 kilograms per capita per year),

$$(5)\qquad x_2 = \frac{q_s}{q_n}\,100,$$

where x_2 is the measure for self-sufficiency, q_s is the quantity of rice supplied per capita (kilograms), and q_n is the quantity consumed per capita (kilograms).

A common measure for consumers' welfare is consumers' surplus. Government officials and economists alike face difficulties in assessing a utility function over this measure. In the case of rice in the Philippines, such a measure can be approximated easily. In particular, for a perfectly inelastic demand, the change in consumer welfare is proportional to the change in the price. Because domestic rice demand in the Philippines is reasonably inelastic, a good approximation to consumer surplus performance measure is provided by

$$(6)\qquad x_3 = P_m,$$

where P_m is the price of rice to the consumer. Given this measure, less of x_3 is preferred to more This feature will be reflected by a monotonically decreasing utility function (see equation [11]). We could, of course, define this performance measure as $1 - P_m$ or $1/P_m$, but this is unnecessary, given that the performance measures enter the utility function as arguments.

The performance measure for price variability is the absolute deviation of the consumers' price from the price in the previous season,

$$(7)\qquad x_4 = |P_{m_t} - P_{m_{t-1}}|,$$

where x_4 is the price variability measure and P_{m_t} is the price to the consumer in period t. The common measure for price variability is the standard deviation of the prices. But once again, a simple measure has been chosen which simplifies the assessment of the decision maker's utility function. Moreover, note that this performance measure does not penalize for large deviations from the previous price. If such penalties exist, they will be reflected by the utility function.

The performance measure for government

[2] We distinguish two production cycles of rice in the Philippines—the dry cycle during which only irrigated rice is planted and the wet cycle during which both nonirrigated and irrigated rice is planted. In order to include nonirrigated farms, the period of analysis will refer to the wet cycle. Since the wet cycle covers only half a year, the period of analysis is referred to as a semester.

expenditures (x_5) is the total expenditures per capita of NGA in executing its policies. These expenditures consist of the (*a*) cost of purchasing palay from the farmers, (*b*) plus the cost of importing rice less the revenues from selling rice to consumers, (*c*) less the revenues from exporting rice, and (*d*) plus the transportation, operating, and storage costs.

Empirical Estimation of the Objective Function

Based on an interview with the former administrator of the Rice and Corn Administration and various members of the current NGA, it was found that the five performance measures are pairwise preferential independent and that at least one performance measure is utility independent. It was also found that additive independence did not exist among the performance measures. This implies (Keeney and Raiffa, p. 344) that the MUF, is the appropriate objective function,

$$(8)\quad 1 + ku(x_1, x_2, x_3, x_4, x_5) = \prod_{i=1}^{5} [1 + kk_i u_i(x_i)].$$

Given equation (8), it is necessary to determine the $u_i(x_i)$ and k_i's for $i = 1, 2, 3, 4, 5$.

The univariate utility functions were assessed by determining the certainty equivalents for 50–50 lotteries. More specifically, we set $u_i(x_i^0) = 0$ and $u_i(x_i^1) = 1$, where x_0 and x_1 are the lowest and highest levels each performance measure i can assume. Then we find $x_i^{.5}$, which is equivalent to a 50–50 lottery between x_i^0 and x_i^1. Then, similarly, we find $x_i^{.25}$, which is equivalent to a 50–50 lottery x_i^0 and $x_i^{.5}$; and, finally, we find $x_i^{.75}$. These five points are the basis for fitting a continuous utility function.

Using the procedure described above, we obtained the following univariate utility functions for the five performance measures:

$$(9)\quad u_1(x_1) = 1.01 - 4.29 \exp(-.00125\, x_1),$$

$$(10)\quad u_2(x_2) = -1.12 + 0.54 \ln(x_2 - 68),$$

$$(11)\quad u_3(x_3) = 0.09 + 0.66 \ln(5 - x_3),$$

$$(12)\quad u(x) = 0.72 \ln(4 - x), \text{ and}$$

$$(13)\quad u_5(x_5) = -4.81 + 1.28 \ln(85 - x_5).$$

As casual observation would suggest, the objective performances, x_1 and x_2, are measured as "goods," while x_3, x_4, and x_5 are measured as "bads." In addition, note that the univariate utility function for farmer net income, x_1, reveals constant risk aversion while all other utility functions, as expected, exhibit decreasing risk aversion. Hence, except for farmer net income, the more favorable the level of the performance measure, the smaller the degree of risk aversion. In the case of farmer net income, decreasing risk-averse functions proved to be poor approximations, while the constant risk-averse function fitted the five points very closely and prevented bias estimates of the minimum farmer net income level.

The scaling constants (weights) of the objective function (k_i's and k) were assessed by equating five different combinations of the various performance measures and using equations (8)–(13) to solve the five equations for the five k_i's and then using

$$(14)\quad 1 + k = \prod_{i=1}^{5} (1 + kk_i)$$

to solve for k. The estimated scaling constants (k_i's) were $k_1 = .8$, $k_2 = .58$, $k_3 = .65$, $k_4 = .52$, $k_5 = .33$, and $k = -1$. Thus, the MUF used in the model is

$$(15)\quad u(x_1, x_2, x_3, x_4, x_5) = 1 - [1 - .8u_1(x_1)][1 - .58u_2(x_2)][1 - .65u_3(x_3)][1 - .52u_4(x_4)][1 - .33u_5(x_5)].$$

Note that all x_i's appearing in (15) are random variables. This randomness relates largely to uncertain rice yields (appearing in x_1, x_2, and x_5) and uncertain prices (appearing in x_1, x_3, x_4, and x_5). Over the relevant ranges, the performance measures have the expected effects on $u(\cdot)$. Increases in both x_1 and x_2 result in larger utilities ("goods"), while increases in x_3, x_4, and x_5 lead to smaller utilities ("bads"). In all instances, except for x_3, these outcomes conform to conventional treatments; increases in farmers' net income (x_1) and production self-sufficiency (x_2) and decreases in price instability (x_4) and government expenditures (x_5) lead to improvements in multiattribute utility. The apparent perverse outcome for the proxy consumer welfare performance measure (x_3) is simply because x_3 is the negative of the consumer well-being measure.

From (15), the trade-offs among the various performance measures can be derived. Because of the preferential and utility indepen-

dence properties of (15), each trade-off is a variable measure of only its own performance levels. For example,

$$(16)\quad \frac{dx_1}{dx_3} = \frac{.0824 + 1.4723e^{(-.00125x_1)}}{(5 - x_3)(-.00429e^{-.00125x_1})} [.9415 - .43 \log (5 - x_3)].$$

The sign on this trade-off is, as expected, $dx_1/dx_3 > 0$; thus, for a constant level of multiattribute utility and all other performance measures, an increase in x_1 must be accompanied by an increase in x_3. The remaining trade-offs over the relevant ranges are $dx_1/dx_2 < 0$, $dx_1/dx_4 > 0$, $dx_1/dx_5 > 0$, $dx_2/dx_3 > 0$, $dx_2/dx_4 > 0$, and $dx_2/dx_5 > 0$, $dx_3/dx_4 < 0$, $dx_3/dx_5 < 0$, and $dx_4/dx_5 < 0$.

Alternative Price Policies

The price policy for rice consists of determining the floor price to the producers (pesos per kilogram of paddy), ceiling price to the consumers (pesos per kilogram of rice), and reserve stock policy. Only the different alternatives of floor and ceiling price will be evaluated. In particular, three forms of NGA intervention will be examined, namely, (*a*) "free market" or no floor or ceiling price policy, (*b*) "complete" intervention under which NGA would import (export) the quantity necessary to drive the market price down (up) to the ceiling (floor) price, and (*c*) "limited" intervention under which NGA attempts to satisfy various forms of free enterprise constraints.

Domestic prices of paddy to producers and consumer rice prices are, of course, uncertain. These uncertain prices depend upon a number of other uncertainties including farm yields, consumer demand, farmers' response, the world market price, and the form of NGA intervention. The free market form involves no domestic price limits, while form (2) requires setting a floor price to producers (P^*_p) and a ceiling price to consumers (P^*_m). For the latter policy intervention scheme, domestic prices are determined by the intersection of consumer demand and producer supply and the margin of the intermediaries, bounded by P^*_p and P^*_m. Because there is empirical evidence that the margin between the retail and the farm price is more or less constant (Castillo; Mangahas, Recto, Ruttan; Mears et al.; Yassour), a fixed margin (P_i) of .45 pesos per kilogram may be imposed.

For complete NGA intervention, policy implementation depends upon two distinguishable cases: (*a*) the floor price to producers plus the intermediaries' margin is greater than or equal to the ceiling price to the consumers,

$$(17)\quad P^*_p + P_i \geq P^*_m,$$

and (*b*) the floor price plus the intermediaries' margin is lower than the ceiling price,

$$(18)\quad P^*_p + P_i < P^*_m.$$

For (*a*), NGA has to intervene regardless of the market behavior. It is assumed that, for those policies which imply relation (17), NGA will subsidize the rice by the amount ($P^*_p + P_i - P_m$) for a kilogram consumed domestically. If the quantity locally supplied is greater (smaller) than needed to meet the ceiling price, NGA will export (import) the surplus (deficiency). Note that, for any level of P^*_m and a particular demand function, there is a corresponding level of q^*_m or quantity (per capita) marketed necessary to achieve the ceiling price. In this instance, $P_m = P^*_m$ and $P_p = P^*_p$, and governmental expenditures are determined by

$$(19)\quad x_5 = q^*_m(P^*_p + P_i - P^*_m) - (q_s - q^*_m)(\delta r P_x - P^*_p - P_i),$$

where P_p is the actual price of rice to the farmer (pesos per kilogram), P_m is the actual price of rice to the consumer (pesos per kilogram), q_s is the quantity locally supplied per capita (kilogram per capita), P_x is the world market price for rice CIF Manila (dollars per kilogram), r is the rate of currency exchange (pesos per dollar), and δ is 1 if $q_s \leq q^*_m$ (CIF) and 8 if $q_s > q^*_m$ (FOB). The first component of the left-hand side of the government expenditures equation is the subsidy paid by the government, and the second component is the revenues (costs) from exporting (importing).

In case (*b*), where relation (18) applies, the market equilibrium is allowed to play a crucial role. In this setting, three possible market scenarios are distinguishable. Scenario 1 is when $P_e < P^*_m$ and $P_e - P_i < P^*_p$, where P_e is the equilibrium price at the consumer level. For this scenario, the consumers' side is satisfied but not the producers'. Hence, in order to meet the floor price to the producers, NGA purchases and exports enough to maintain the domestic floor price. In this instance, NGA would export the quantity $q_s - q^*_p$, $P_p = P^*_p$, $P_m = P^*_p + P_i$, $P_m < P^*_m$, and

$$(20)\quad x_5 = (q_s - q^*_p)(P^*_p + P_i - .8rP_x),$$

where q^*_p is the quantity marketed necessary to meet the floor price for the realized demand function.

Scenario 2 is when $P_e < P_m$ and $P_e - P_i > P^*_p$. In this scenario, since both sides are satisfied, NGA would not intervene in the market. The prices would be $P_m = P_e$, $P_p = P_e - P_i$, and government expenditures would be zero.

Scenario 3 is when $P_e > P^*_m$ and $P_e - P_i > P^*_p$. For this scenario, the producers' side is satisfied but not the consumers'. In order to meet the ceiling price to the consumers, NGA would import the quantity $q^*_m - q_s$. Prices would be $P_m = P^*_m$, $P_p = P^*_m - P_i$, $P_p > P^*_p$, and government expenditure is determined by

$$(21) \qquad x_5 = (q^*_m - q_s)(rP_x - P^*_m).$$

For limited forms of NGA intervention, policies are constrained by desires to keep the amount of involvement in the private sector at some minimal satisficing level. These forms of intervention presume that NGA is reluctant to implement a policy which implies fixed prices to farmers and consumers and an associated large subsidy program. Since limited involvement in the rice industry of the Philippines was not treated as one of the measurable objectives, trade-offs between the rate of governmental involvement and the other performance measures are not available.[3]

Three specifications of the limited involvement constraint will be examined. The first severely limited NGA involvement by requiring no direct government subsidies. Recall that direct government subsidies are required whenever the consumer price is lower than the farm price plus the intermediaries' margin. Hence, no direct government subsidies are required when $P^*_p/.61 + P_i < P_m$, where .61 is the rate of recovery from paddy to rice. A second specification limits the producer floor price to no more than 1.20 pesos per kilogram, i.e., $P^*_p \leq 1.20$. Finally, a third specification combines these two constraints as the satisficing levels for the limited involvement objective. Note that, for each of these specifications, the shadow price of the corresponding constraint may be computed; on the basis of these computations, NGA and the government of the Philippines can make an informed judgment of whether or not the corresponding limited involvement objective justifies its costs.

[3] The constraints implied by the desire for such limited involvements may be regarded as the highest objective in a lexicographically ordered criterion function with the second objective measured by the MUF (15); i.e., given the satisfaction of a limited involvement constraint, proceed to maximize $EU(x_1, x_2, x_3, x_4, x_5)$.

Uncertainty: Weather

A subjective probability distribution was assessed for the nature conditions variable with three possible outcomes: "bad"—production is 10% below normal; "moderate"—production is normal; and "good"—production is about 10% above normal. Based on the assessments of NGA officials, agricultural economists, and farmers, the probability distribution used in the analysis was good nature conditions, $p = .2$; moderate nature conditions, $p = .5$; and bad nature conditions, $p = .3$. A more objective analysis of rice yields (Yassour) resulted in a similar distribution.

Uncertainty: Farmers' Response

Two types of farms are distinguished here: irrigated and nonirrigated. For the irrigated farms, the farmers usually grow more than one crop per year; these are less vulnerable to nature conditions and are more profitable. The nonirrigated farms, however, are less intensively cultivated. Most of them are in areas far from the big marketing centers and are less flexible in their marketing options.

NGA officials and Filipino agricultural economists have been asked to assess the response of farmers who grow rice in irrigated and nonirrigated farms to different levels of floor price for paddy. Their assessments are summarized in table 1.

Uncertainty: Demand

Uncertain demand arises with respect to both its functional form and the price elasticity. The uncertain functional form was admitted by specifying both linear and Cobb-Douglas forms. In the case of price elasticities, the findings of Mears, Nasol, and Apiraksirikul show that the price elasticity of demand for rice in the Philippines ranges from $-.2$ to $-.5$. By substituting the current quantity consumed per capita per year (100 kilograms) and the current consumer price (2.10 pesos per kilogram) in linear and Cobb-Douglas functions, the respective demand functions were obtained. A subjective probability distribution was then assigned over the elasticities. This was done with the advice of the researchers in the Department of Agricultural Economics of

Table 1. Subjective Assessments of Probability Distributions of Farmers' Response to Different Levels of Floor Price

	Probability					
	Irrigated			Nonirrigated		
Floor Price	.25	.5	.25	.25	.5	.25
	(% of production[a])					
1.00 peso per kilogram	92	97	102[b]	95	98	101
1.10 pesos per kilogram	100	100	100	100	100	100
1.20 pesos per kilogram	102	104	106	100	101.5	103
Free market[c]	99	100	101	97	99	101

[a] Farmers intend to grow 100% production under the current floor price (1.10 pesos per kilogram). This basic figure differs for irrigated and nonirrigated farms.
[b] Higher production for lower price was explained by the fact that there is a group of farmers who place a high value on leisure time. The quantity those farmers produce is that which is sufficient to cover their basic needs. Prices at the level of 1.00 peso per kilogram force them to produce more in order to meet their subsistence level.
[c] This row represents the subjective assessment of how farmers would behave if the floor price policy were terminated and the free market would operate to determine producer prices.

the University of the Philippines, Los Banos, and of the International Rice Research Institute. The elasticities to be analyzed in the model, their respective demand functions, and their probabilities are shown in table 2.

In order to avoid skyrocketing prices for very small quantities as a result of an exponential demand function and negative prices for very large quantities as a result of a linear demand function, the demand function was specified as linear to the left of the current quantity consumed (100 kilograms per capita per year) and exponential to its right.

Uncertainty: World Market Price of Rice

The price NGA would pay (receive) for imported (exported) rice is also a random variable. Based on their knowledge about the situation of rice and grains in the international market, NGA officials provided the probability distribution shown in table 3 for the year 1978.

The prices in table 3 include the cost of the rice itself, sea transportation and insurance, and transportation from the port to the warehouse. The price that NGA would receive for one ton of exported rice (FOB) is, of course, lower. NGA officials estimated that, for the same quality of rice, the export price per ton would be lower than the import price by about 20%.

Empirical Results

The NGA decision problem under the uncertainties discussed above is shown in decision-tree form in figure 1 for cases of $P^*_p = 1.20$ and no intervention.[4] At each end point of

[4] The following data were used in analyzing the model: average family size of a rice-growing farm is 6.5 (Hayami et al.); current yearly consumption of rice is 100 kilograms per capita (Aviguetero): rate of recovery from palay to rice is .61; wet season production is 62.5% of the total yearly production; yield of irrigated and nonirrigated farms is 2.25 and 1.5 tons per hectare, respectively (45 and 30 cavans per hectare); the number of irrigated and nonirrigated farms is 360,000 and 600,000, respectively, with an average farm size of 2.5 hectares; current price to consumers is 2.10 pesos per kilogram (Alix, Kunkel, Gonzales); cost of labor per irrigated and nonirrigated hectare is 400 pesos per hectare and 300 pesos per hectare, respectively; cost of inputs is 400 pesos per hectare and 250 pesos per hectare, respectively (NGA files); and exchange rate is 7.3 pesos per dollar.

Table 2. Price Elasticities of Demand for Rice, Demand Functions, and Probabilities

	Demand Function		
Price Elasticity	Exponential	Linear[a]	Probability
−.2	$P = (116/q)^5$	$P = 12.60 - .105q$	.3
−.3	$P = (125/q)^{3.33}$	$P = 9.10 - .07q$	.3
−.4	$P = (135/q)^{2.5}$	$P = 7.10 - .05q$	.3
−.5	$P = (145/q)^2$	$P = 6.10 - .04q$	.1

[a] The linear demand functions are the linear approximations of the exponential functions at the region of the current price and quantity consumed per capita.

Table 3. Subjective Probability Distribution of World Market Price for Rice

Price of Imported Rice	Probability
CIF, \$/ton	
250	.1
270	.2
300	.4
330	.2
350	.1

Source: Personal communication with National Grains Authority, Department of Corporate Planning.

the decision tree for these as well as all other alternatives, we have the levels of each performance measure, x_i. These performance measures depend on the policy and the relevant uncertainties, reflected by probability measures representing the chance of reaching a particular end point. The values of the five performance measures, together with the univariate utility functions (9)–(13) and the probability distributions, are then used in (15) to compute the expected utility for each policy. The analysis was conducted for feasible floor prices ranging from 1.00 to 1.50 pesos per kilogram of paddy and ceiling prices ranging from 1.70 to 3.10. This was done for the complete and limited forms of NGA intervention.

A complete intervention policy involving a floor price set at 1.40 and a ceiling price set at 2.10 maximizes expected utility; for this policy, $EU = .96984$. For a .61 rate of recovery from palay to rice and an intermediaries' margin of .45 peso, this policy generates a price at the consumer level of 2.74 and thus implies a subsidy of .64 peso per kilogram. This policy, along with the limited intervention policies, proved superior to the free market policy which generated an expected utility of .95569.

For the "limited" involvement of no direct government subsidies, i.e., $P^*_p/.61 + P_i < P_m$, the optimal solution is $P^*_p = 1.30$ and $P^*_m = 2.90$, which generates an expected utility of .96696. For the second limited involvement specification, i.e., $P^*_p \leq 1.20$, the optimal policy is $P^*_p = 1.20$ and $P^*_m = 2.10$, with expected utility falling to .96678. This policy implies a direct government subsidy of .32 peso

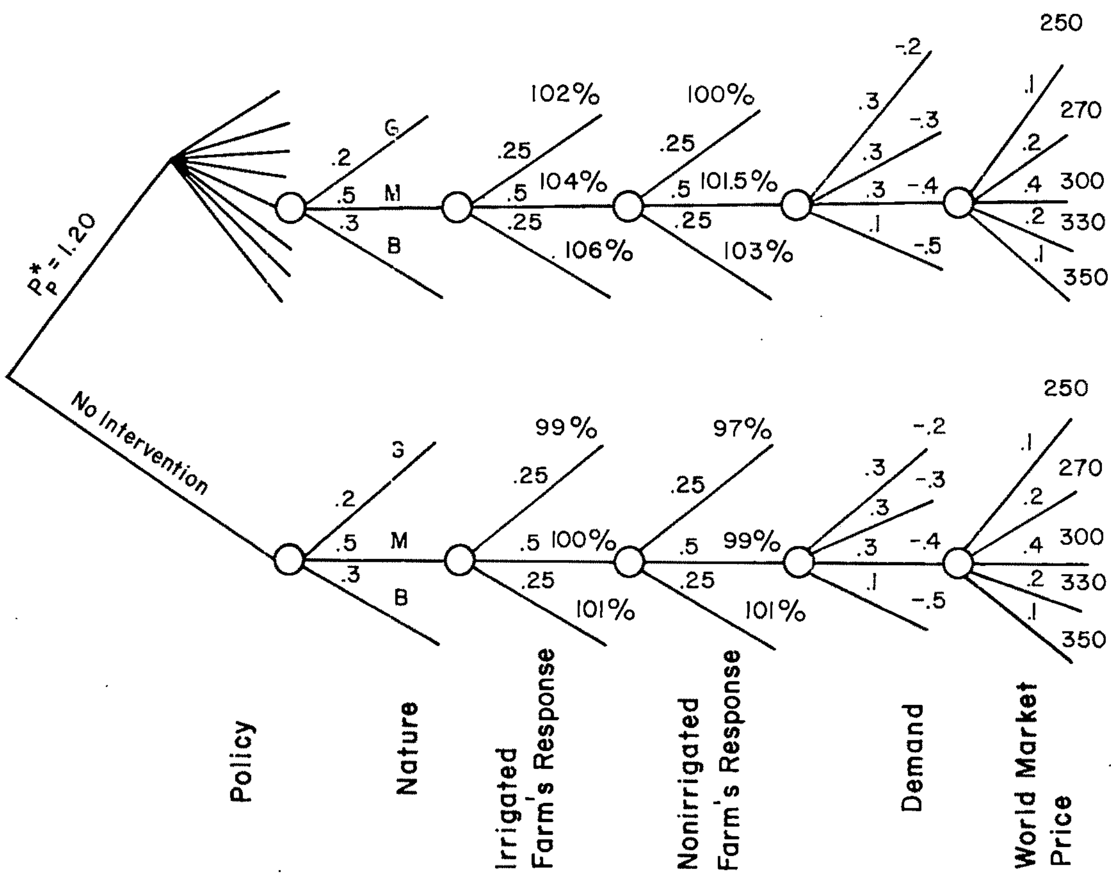

Figure 1. The decision tree

per kilogram of rice. Finally, for both constraints, $P^*_p/.61 + P_i < P_m$ and $P^*_p \leq 1.20$, the optimal policy is $P^*_p = 1.20$ and $P^*_m = 2.90$, and the expected utility is .96675.

A comparison of the various policies reveals small differences in the expected multiattribute utility. This is due to the assessment procedure of the Keeney and Raiffa approach, which bounds U between zero and unity. The small differences may imply large movements in the certainty equivalents for each performance measure, x_i. In sorting out the implications of the expected multiattribute utility in terms of the individual performance measures, however, some obvious difficulties arise. The scaling constants, multiple performance measures, trade-offs, and associated univariate utility functions complicate the relationship between EU and any particular x_i. To obtain consistent results, one way to proceed would be to fix the level of four performance measures and, given EU, solve equation (15) for the remaining performance measure.

For example, fixing x_2, x_3, x_4, and x_5 at levels for which $u_i(x_i) = .84$, $i = 2, 3, 4, 5$, where the value .84 for $EU_i(x_i)$ was chosen to stay within the original range of the attributes, we can derive the complete intervention expected utility equivalent measure for x_1. It is $x^*_i = 2{,}642$. Proceeding in this fashion, expected utility equivalents for the remaining x_i's can be obtained for each policy. These results are reported in table 4. Note that a higher floor price results in a lower expected-utility-equivalent measure for governmental expenditures. This is because all the gains from increased floor prices (namely, farmers' net income and self-sufficiency) are translated into savings in the governmental expenditure policy equivalent measure. To be sure, increased floor prices lead to larger actual governmental expenditures; but the gains in other performance measures, when translated into the utility equivalents for government expenditures, more than compensate for its actual increase.

The above approach allows policy debate to take place in terms of individual performance measures—namely, their utility equivalents—rather than the more obscure multiattribute utility measures. For example, in comparing the current policy (1.10, 2.10) with the maximum floor-price, limited intervention policy (1.20, 2.10), the difference in expected utilities will have little meaning to policy makers. However, a "utility equivalent" difference of 39.5 pesos less 11.5 pesos per capita, or 1,232 million pesos for the total population, is more revealing.[5] This means that, in terms of the criterion function (15) incorporating all performance measures, a utility equivalent comparison of government expenditures results in savings of 28 pesos per capita. Similar multiattribute utility comparisons can be made in terms of the remaining performance measures.

Sensitivity Analysis

Sensitivity analysis was conducted for a number of important variables. As expected, it was found that higher expected utilities resulted in

[5] The figure 11.5 pesos per capita was derived by substituting .96678 for EU on the left-hand side of (15) and .84 for all $EU_i(x_i)$, $i \neq 5$, thus obtaining $EU_5(x_5) = .69$. Substituting the computed value .69 into (13), we find $x^*_5 = 11.5$ pesos per capita. A similar procedure is followed for all expected utility equivalent measures, x^*_i.

Table 4. Comparisons between Current, Complete, and Various Limited Forms of NGA Intervention

	Current Policy [1.10, 2.10]	Complete [1.40, 2.10]	Limited: No Direct Subsidies [1.30 2.90]	Limited: Maximum Floor Price [1.20, 2.10]	Limited: Maximum Floor Price and No Direct Subsidies [1.20, 2.90]
Expected utility	.95809	.96984	.96496	.96678	.96675
Value of:[a]					
x^*_1 (pesos)	2,095	2,642	2,470	2,460	2,458
x^*_2 (%)	89.3	107.6	102.0	101.7	101.6
x^*_3 (pesos/kg.)	2.84	1.78	2.08	2.10	2.11
x^*_4 (pesos/kg.)	2.10	.64	1.08	1.10	1.11
x^*_5 (pesos per capita)	39.5	−1.9	10.8	11.5	11.7

[a] The values of x^*_i result in the above expected utility when the values of the other performance measures are fixed such that $u_j(x_j) = .84$, $j \neq i$ ($x_1 = 2{,}853$ pesos, $x_2 = 105.7\%$, $x_3 = 1.38$ pesos/kg., $x_4 = .79$ pesos/kg., and $x_5 = 2.40$ pesos per capita).

lower consumption, decreased population, higher yields, more rice farms in general, and more irrigated farms in particular. Generally speaking, the floor price of the optimal policy decreased as the total production increased. Because of space limitations, we report here only the sensitivity analysis performed on the responsiveness of farmers to changes in the floor price and the potential instability in the trade-offs among alternative performance measures. Because the sample data did not include a floor price above 1.20 pesos per kilogram, a number of alternative assumptions were investigated. The results for the conservative assumption that farmers' response to floor prices above 1.20 pesos per kilogram would be the same as for 1.20 pesos per kilogram clearly indicate that a 1.40 floor price and 2.10 ceiling price for the complete intervention scheme dominates all alternatives examined (floor prices range from 1.00 to 1.30 pesos per kilogram and ceiling prices from 1.70 to 3.10 pesos per kilogram). The second-best policy was [1.50, 2.10].

With respect to potential instability in performance measure trade-offs, significant changes in NGA membership composition or interest group influence will be reflected in the scaling constants. Initially, these constants were determined as follows: $k_1 = .8$, $k_2 = .58$, $k_3 = .65$, $k_4 = .52$, and $k_5 = .33$. In the sensitivity analysis, all 243 possible combinations of $k_1 = .9, .8$, and $.7$; $k_2 = .7, .6$, and $.5$; $k_3 = .75$, $.65$, and $.55$; $k_4 = .6, .5$, and $.4$; and $k_5 = .45$, $.35$, and $.25$. Of the 243 combinations examined, 75 resulted in [1.50, 2.10] as the best policy; 47 in [1.40, 2.10]; 26 in [1.30, 2.10]; and 21 in [1.20, 2.70]; the remaining 74 combinations resulted in seven other policies. The optimal policy was sensitive mainly to the values of k_1 and k_5.

Conclusion

This paper illustrates an approach to public policy analysis emphasizing uncertainty and conflicting objectives. The framework seems especially appropriate for public policy problems frequently encountered in agriculture and food systems. Its principal value may be to provide focus on the major conflicts, trade-offs, and subjective perceptions among affected groups. It can be used to isolate major disagreements, needed empirical evidence, appropriate degrees of risk aversion, equity value judgments, consensus solutions, and the like.

Determining price policy for rice in the Philippines served as an illustration of the framework. Here, the optimal complete intervention policy consisted of a floor price of 1.40 pesos per kilogram and a ceiling price of 2.10 pesos per kilogram. This policy implies fixed farm and retail prices and a subsidy of .64 pesos per kilogram. Such a policy requires major changes in NGA operations and administration. Moreover, it contradicts free-enterprise ideals. Therefore, as a first stage, NGA might implement a policy in which the floor price is 1.30 pesos per kilogram and the ceiling price is 2.70 pesos per kilogram. This does not imply fixed prices or direct government subsidies ($1.30/.61 + .45 < 2.70$). A ceiling price of 2.70 pesos per kilogram at the farm may result in a sharp increase in the consumer price. The probability of such an increase, however, is lower under the suggested policy than under the current policy. This is because of the expected higher production occurring response to the higher floor price. In the unlikely case of a nationwide disaster, NGA could launch a temporary emergency program of direct government subsidies.

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Predicting the Diffusion of Improved Pastures in Uruguay

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Research suggests the logistic curve is the characteristic diffusion path for new technologies. Econometric analysis of fertilized grass-legume pastures in Uruguay indicated that their diffusion during the first years following introduction also followed a logistic path. Some departure from a simple logistic shape was explained by including beef and fertilizer prices within the diffusion framework. Both the rate and limit of diffusion were positively related to changes in the technology's profitability, but the estimated price elasticity of each was low. Extrapolation predicted that a ceiling equal to 12% of Uruguayan pasture area would be reached in 1980.

Key words: diffusion, logistic curve, new technology, pastures, prediction, Uruguay.

This paper analyzes the diffusion of improved pastures in Uruguay, a development promoted since 1961 by a joint Government of Uruguay/World Bank lending and technical assistance project (Hirschman, Jarvis 1976). The cumulative growth in the number of ranchers who have adopted this technology and total area planted to improved pastures is explained by fitting the diffusion data to logistic curves. However, the diffusion process is analyzed before diffusion has ceased. Total diffusion and the date at which the ceiling is achieved are predicted using observations from the first years of the process. Beef and fertilizer prices are incorporated into the analysis to obtain improved estimates of future diffusion.

The introduction of fertilized grass-legume pastures increased livestock output about 18% between 1961 and 1975, two-thirds of the entire increase (Jarvis 1976). Fertilized grass-legume pastures are the principal, feasible means to higher Uruguayan livestock production and exports. Annual gross pasture investments rose from 18,000 hectares in 1961 to 320,000 hectares in 1973, the historical peak. Cumulative net pasture improvements reached 1.64 million hectares in 1975, 11.5% of the total pasture area (table 1). By 1975, total adopters numbered more than 15,000, or more than half the potential (table 1). Nonetheless, the increase in area planted to improved pastures has been slower than hoped. Improved pasture use is still much less than in New Zealand (62% of pasture area), the source of this particular technology.

In 1975, the rate of pasture investments was declining. A sharp decline in beef prices had occurred, making the two phenomena appear related. Some experts believed that a recovery of beef prices would cause a recovery in pasture investments. Because this belief was important for government policy and relevant to future World Bank lending in Uruguay for livestock development, the following hypotheses were tested. (*a*) The rate and the limit of technology diffusion can be predicted with information from the first years following introduction. (*b*) The rate and the limit of diffusion are positively related to changes in the technology's profitability.

The Model

Several studies analyze the diffusion of new technologies, e.g., Griliches and Mansfield. Because these studies observed a characteristic diffusion path, I wanted to determine if the diffusion of improved pastures in Uruguay followed the same pattern. If so, perhaps the

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Table 1. Adopting Ranchers, Pasture Improvements, and Beef Prices

Year	(1) New Adopters	(2) Cumulative Adopting Ranchers	(3) Annual Gross Pasture Investments	(4) Cumulative Pastures In Production[a]	(5) Pasture Depreciation[b]	(6) Annual Net Pasture Investments[c]	(7) Beef Prices[d]
			(thousand hectares)				
1960				120			143
1961	141	141	18	128	10	8	98
1962	120	261	24	136	11	13	86
1963	136	397	32	149	12	20	79
1964	300	697	68	169	14	54	91
1965	247	944	91	224	18	73	116
1966	501	1,455	130	297	24	106	126
1967	615	2,060	145	403	32	113	92
1968	1,187	3,247	225	516	41	184	72
1969	2,037	5,284	200	700	56	144	73
1970	1,815	7,999	160	844	68	92	85
1971	2,455	9,554	270	936	75	195	108
1972	1,911	11,465	320	1,131	90	230	143
1973	2,302	13,767	308	1,361	109	199	126
1974	911	14,678	282	1,560	203	79	101
1975	320	14,998	101	1,639	230	−129	61
1976	475	15,473	87	1,510	227	−140	44
1977			95	1,370	195	−100	65
1978			91	1,270			60

Sources: Col.(1), author's estimate using information from Banco de la Republica; col.(2), from col.(1); col.(3)–(6), Plan Agropecuario; col.(7), Ministry of Agriculture.

[a] Col.(4)$_t$ = [Col.(3) + Col.(4) − Col.(5)]$_{t-1}$.

[b] Col.(5) = (.08)Col.(4) for 1961–73; from agricultural sample surveys for 1974–77.

[c] Col.(6) = Col.(3) − Col.(5).

[d] Index of real producer price (average price 1960–79= 100) for steers, per kilo liveweight at slaughterhouse. Nominal producer price was deflated by Montevideo cost-of-living index.

future of pasture investments could be predicted by extrapolation. These studies showed that the cumulative adoption path often behaves like a logistic curve (fig. 1). Diffusion begins when the technology first becomes available (t_0). The number of adopting producers increases slowly at first, because only the most progressive and/or less risk-averse adopt. Then it increases more rapidly as information spreads to other producers. Finally, it slows when nearly all producers who will find the technology profitable have adopted, the process reaching an essentially stable ceiling (t_-).

The logistic function traces diffusion toward an equilibrium by assuming that the technology's profitability remains constant. Because diffusion often requires twenty years, it would be surprising if changes in prices, technology, and learning over time did not seriously affect the diffusion process and distort its profile away from a simple pattern. The issue is worth further research. In this paper, the logistic is accepted as a starting point because of its mathematical simplicity. However, some departure from a simple logistic shape will be explained by including other variables within the diffusion framework.

The logistic curve is defined as follows:

$$Z_t = \frac{K}{1 + e^{-c-\phi t}}, \tag{1}$$

where Z_t is cumulative number of adopters by time t; K is ceiling, i.e., the total ranchers adopting by the time the diffusion process ceases ($[K/T]$ is the final percentage of the ranchers expected to adopt, where T is total potential adopters); ϕ is the rate at which diffusion occurs; and c is a constant term.

Previous economic studies attempted to show that diffusion conformed to the logistic shape and that variations in the diffusion rate and the ceiling reached (among different processes) were related to observed economic variables. Analysis occurred after diffusion had ceased and a stable ceiling was observable. Thus, only the diffusion rate was estimated. In this study, because the ceiling had not been reached, both the ceiling and the rate of diffusion were estimated simultaneously.

Characterizing the Diffusion of Improved Pastures

Consider first adoption by individual ranchers. The number of new farmers borrowing each year from the Bank of the Republic (BROU) for pasture development is used as a proxy for new adopters. A high proportion of adopters borrowed from the BROU to make their first investment. The BROU offered very favorable credit terms within an otherwise very restrictive financial context, and requests for BROU credits were handled rapidly. BROU credit recipients also received good technical assistance from the Plan Agropecuario (PLAN), which coordinated the livestock development project. About 15,000 different ranchers received credits between 1961 and 1976 (Jarvis 1977). The timing of their first loans is given in table 1.

The information on borrowers provides a good estimate of total adopters and, more important, the rate at which new adopters appeared over time. A few ranchers probably made their first pasture investments without borrowing from the BROU, but the BROU data are consistent with the number of adopting ranchers that appears in the 1970 Agricultural Census and in several recent sample surveys (Alonso and Perez).

By rearranging equation (1), we obtain

$$\frac{Z_t}{K - Z_t} = c^{c+\phi t}, \tag{2}$$

which, if K is known, can be estimated linearly in logarithms. Because K was not known, equation (2) was estimated by varying K parametrically from 10% to 100% of the total producers considered potential adopters (29,000).[1] The equation yielding the highest R^2 was assumed to give the best conditional estimates for K and ϕ. The best estimate suggests that the logistic curve reflects closely the adoption of improved pastures by Uruguayan ranchers (table 2). In equation (2), which is an autoregressive transformation of equation (1), R^2 is maximized at $K/T = 0.56$. This implies that 56% of Uruguayan producers will eventually adopt, with 90% of the ultimate ceiling being reached in 1975, and 99% in 1979.

These results have two implications: (*a*) a majority of potential adopters have invested in

[1] Of the 77,000 farms and ranches in the 1970 agricultural census, the BROU considered 29,000 potential borrowers. Farms with less than 10 hectares (23,000) were excluded as too small. Larger farms in areas where livestock is not produced (13,000) and farms having title or credit problems (12,000) also were excluded. The 29,000 farms considered potential borrowers control 85% of total agricultural area.

[2] The difference of beef price from its mean was used, preserving the comparability of the constant term with that in previous regressions. Price was lagged one year; decisions regarding pasture investments are usually made at the end of one year for implementation early in the next.

Table 2. Estimated Logistic Curves (Log-Linear Method)

	C	ϕ_0	ϕ_1	K/T	R^2	DW	Rho
Ranchers adopting:							
1)	−35.85	0.51		0.56	.996	0.91	
	(63.87)	(62.29)					
2)	−35.61	0.51		0.56	.997	1.57	0.56
	(28.24)	(28.23)					
Hectares planted:							
3)	−21.03	0.30	0.08	0.14	.976	0.91	
	(24.76)	(24.06)	(3.77)				
4)	−19.80	0.28	4.03	0.14	.979	1.24	0.69
	(7.06)	(7.07)	(2.75)				

Projection of Future Adoption

	K	K/T	$0.09K$[a]	0.99K	From
Ranchers adopting:	16,499	0.56	14,900 (1975)	16,350 (1979)	table 2, eq. (2)
Hectares planted:					
a)	1,960,000	0.14	1,765,000 (1978)	1,940,400 (1987)	table 2, eq. (4)
b)	1,660,000	0.12	1,491,000 (1975)	1,640,000 (1980)	table 3, eq. (6)

[a] Date when the projected percentage of ceiling is reached is given in parentheses.

improved pastures, confirming that information on pasture use and profitability is widespread; (*b*) the entry of new adopters is now small and declining. Unless some fundamental factor is altered, few additional adopters will appear.

Nonetheless, improved pasture area could expand on ranches where adoption has already occurred. In fact, it was originally expected that Uruguayan adopters would begin with small investments and steadily increase the proportion of their ranches devoted to improved pastures until a high proportion of total pasture area had been converted. Such was the experience in New Zealand under similar conditions. Some expansion of planted area has occurred on adopting ranches in Uruguay, but it is important to test if this expansion will continue.

Improved pastures, once established, can be productive indefinitely if properly managed and refertilized. Pastures of twenty years and more are common in New Zealand, but intensive pasture management requires an approach different from the extensive ranching traditionally practiced in Uruguay. Also, beef prices are not sufficiently high to make improved pastures profitable enough to induce farm intensification, as once thought possible (Hirschman). Thus, pasture deterioration in Uruguay has been more rapid than in New Zealand. Estimated at about 8% per year until 1974, Uruguayan pasture deterioration has been even higher since then, due to overgrazing and reduced refertilization during the livestock crisis which began in that year. Depreciation reduces net investment significantly below gross investment, especially since the total stock of improved pastures has grown (table 1). Although 2.8 million hectares were planted prior to 1977, only 1.3 million were still in production at that date.

Net pasture improvement is the variable of interest. Fortunately, the data on both annual investments and depreciation are good. The PLAN has monitored closely a large sample of ranches over the last fifteen years. The resulting depreciation estimates are consistent, at the national level, with data from agricultural census and subsequent sample surveys.

The cumulative net hectares of improved pasture in production were fitted to a logistic equation using the same procedure followed for ranch adopters. R^2 was maximized at a ceiling equal to 18% of the area assumed suitable for improved pastures (14 million hectares). However, serial correlation was present even after an autoregressive transformation, making the estimated coefficients statistically insignificant. Other variables, like prices, then were included in the analysis.

The Effects of Prices on Diffusion

Previous studies recognized that diffusion could be affected by variables such as prices. Griliches showed that the diffusion rate of hybrid seeds in different farming areas were positively related to the increased profit achieved by the farmers introducing the new seed. Mansfield (1961) showed that diffusion rates of various technologies in several industries were positively related to the profitability of the new technologies. I am not aware of research in which the diffusion rate of a single innovation has been expressed as a function of economic variables, although Mansfield (1968, p. 140) suggests this possibility.

Beef prices in Uruguay oscillated markedly between 1960 and 1978 (table 1). Because a return from low prices in 1975–76 to normal market conditions could encourage wider diffusion, the logistic was reformulated to estimate directly the effect of price on hectares planted.

First, only ϕ, the rate of diffusion, was made a function of beef price. Letting $\phi = \phi_0 + \phi_1 P$,[2] equation (1) becomes

$$(3) \qquad Z_t = \frac{K}{1 + e^{-c-\phi_0 t-\phi_1 Pt}}.$$

The inclusion of prices improves the results (table 2, equations [3] and [4]). The regressions were carried out with and without an autoregressive transformation; in both cases, the Durbin-Watson statistic is in the indeterminate range. The price coefficient is positive and significant at the 2% level, assuming no serial correlation. Iterating over K yielded maximized R^2 at $K/T = 0.14$. Assuming no change in the technology's profitability, 90% of the ceiling would be reached in 1975 and 99% in 1980.

An iterative nonlinear least-squares method was used next, permitting a direct estimate of K. Thus both ϕ and K are specified as functions of the beef price. This estimator is probably more efficient than the log-linear (Oliver). The specification also was slightly changed by assuming that diffusion followed a nonlogistic path until 1961, when the livestock develop-

ment project was initiated, and afterwards a logistic path (Economides). Much experimentation was required before the new pasture technology was adequately adapted to Uruguayan climate and soils. Diffusions along a logistic path probably did not begin until 1965. Slow growth between 1961–65 skews the diffusion slightly from a true logistic.

$$(4) \qquad Z_t = mT + \frac{k_0T + k_1PT}{1 + e^{-c\phi_0 - \phi_1 Pt}},$$

where $m + k_0 = K/T$.

Equation (4) was estimated for both adopting ranchers and for planted hectares with different zero restriction on the values of m, k, and ϕ_1 (table 3). M is significant at the 5% level only once for adopting ranchers but nearly each time for planted hectares. In the latter case, this formulation reduced the Durbin-Watson statistic.

When only ϕ is a function of beef price, the price coefficient is positive but not significant for either adopting ranchers or planted hectares. Price had little impact on the rate of diffusion. When only K is a function of price, the price coefficient is positive and significant at the 1% level for both adopting ranchers and planted hectares. Price had an impact on the ceiling. Correcting for slight heteroscedasticity did not affect the parameter estimates.

When both K and ϕ are functions of beef price, the results are not completely satisfactory; the functional form chosen cannot fully characterize the price effect. For adopting ranchers, neither coefficient is statistically significant; while for hectares planted, both are statistically significant. The coefficient on k_1 is positive and that on ϕ_1 is negative. The sign on ϕ_1 changes. Because the ceiling is sensitive to price and the diffusion rate is not, the increased ceiling (resulting from a price increase) must be associated with a longer diffusion period. With the formulation used, ϕ_1 must have a negative sign. This does not imply that a price increase itself causes the diffusion rate to decline.

The estimated ceilings for the two diffusion processes are quite similar for both the nonlinear and the log-linear methods. For adopting ranchers, both methods estimate a ceiling of about 0.56. For planted hectares, the nonlinear method provides the only significant estimate, about 0.115, slightly lower than the statistically insignificant estimate provided by the log-linear method. The diffusion rate estimated by the nonlinear estimator is significantly higher than that estimated by the log-linear method for hectares planted, but about the same for adopting ranchers.

All estimates suggest that diffusion will reach a ceiling well below the area the government of Uruguay believed feasible. Beef

Table 3. Estimated Logistic Curves (Nonlinear Method)

	m	k_0	k_1	C	ϕ_0	ϕ_1	$\bar{R}^2$	DW
Ranchers adopting								
Equation (1)		0.5539		−39.63	0.5632		.999	1.58
		(70.43)		(30.26)	(29.57)			
(2)	.0079	0.5400		−41.86	0.5947		.999	2.07
	(2.16)	(59.13)		(25.58)	(25.33)			
(3)		0.5525		−39.18	0.5571	1.1859	.999	2.16
		(74.72)		(32.45)	(31.73)	(1.86)		
(4)		0.5597	0.1856	−38.32	0.5441		.999	2.16
		(82.70)	(3.07)	(36.06)	(35.17)			
(5)		0.5609	0.2103	−38.24	0.5429	−0.2495	.999	2.18
		(64.42)	(1.84)	(33.30)	(32.27)	(0.27)		
Planted hectares								
(6)		0.1182		−27.79	0.4040		.971	0.80
		(17.12)		(8.09)	(7.80)			
(7)	0.0089	0.1042		−36.20	0.5243		.976	0.96
	(2.32)	(13.46)		(5.66)	(5.63)			
(8)	0.0083	0.1042		−36.43	0.5287	5.1606	.977	1.26
	(2.34)	(13.99)		(5.45)	(5.40)	(1.63)		
(9)	0.0073	0.1063	0.1792	−33.64	0.4881		.997	2.66
	(5.16)	(36.33)	(10.03)	(16.17)	(16.17)			
(10)	0.0065	0.1097	0.2293	−31.51	0.4553	−2.6444	.988	2.82
	(4.79)	(32.47)	(7.33)	(16.32)	(16.09)	(2.26)		

price variation influences the number of ranchers finding the technology profitable and the amount planted by those who adopt. However, each influence appears small. The price elasticity of K/T for adopting ranchers is only about 0.05, and for planted hectares about 0.3.[3] Thus, given an estimated ceiling of 11.5% of total pasture area under mean price conditions, increasing the beef price by 10% would increase the ceiling only from 11.5% to 11.8%. Doubling the beef price would increase the ceiling only to 15%.

To study the diffusion rate further, residuals from the simple logistic, estimated by both the log-linear and the nonlinear estimators, were regressed on a series of variables. These variables included beef price in year t and year $t-1$, the fertilizer price (net of government subsidy) in year t and $t-1$, the inflation rate, and the Central Bank index used to adjust principal and interest payments on pasture improvement loans. No variable except beef price had a statistically significant coefficient.[4] A more significant coefficient was obtained when beef price was multiplied by a time trend. As more ranchers each installed more improved pastures, a higher proportion of pastures became marginally profitable and are therefore sensitive to price variation. In the period 1960–76, beef prices explain 60% of the residual variation for the nonlinear estimator. Nonetheless, the total variation about the logistic curve is small when compared with the pattern predicted by the logistic itself.

The Sensitivity of the Logistic Coefficients to Period Variation

Estimating the logistic curve for different subperiods, beginning with 1961–76 and subtracting one year at a time, permitted analysis of coefficient sensitivity to changing numbers of observations. Using the nonlinear method, reasonably similar coefficient estimates significant at the 1% level were obtained for the period 1961–71 through 1961–76. The estimates for the periods 1961–69 and 1961–70 were statistically insignificant; no estimates were sought for earlier periods.[5] It appears that an inflection point must be reached before stable coefficient estimates emerge.

The estimates of K/T for various periods vary only slightly, from 0.10 to 0.15. The highest estimate exceeds the lowest by 50%, but both are low relative to the total number of hectares considered suitable for improved pasture. Thus, estimation of the logistic curve would have indicated by 1971 that the ceiling would be low. Even during the period of favorable prices and high annual net pasture investments, 1971–73, the estimated ceiling did not increase radically. The government therefore might have gained several important years by recognizing that diffusion was to be more limited than expected. It then could have devoted more resources to studying the factors limiting diffusion and developing policies for increasing it.

Further Implications of the Price Coefficients

Cattle producers in Uruguay have experienced extreme beef price cycles during the last two decades. These cycles probably explain the low estimated price elasticity of pasture improvement. Because producers are accustomed to wide price cycles, producers' price expectations likely contain both a mean and a cyclical component. If so, producers are unaffected in their long-run investment plans by price variations which do not alter the mean price component. Relatively small adjustments are made only when a permanent change in the mean price is expected.

Even so, the effect which price variations have had on diffusion during recent years can be outlined briefly (fig. 1). In 1975, the total stock of improved pastures peaked at about 1.6 million hectares, or 11.5% of total pasture area. The planted area declined since 1975, to about 1.3 million hectares in 1978, or 9% of total pasture area. The 1975 figure reflects the impact of high prices during the period 1972–74, which raised the expected ceiling temporarily to about 13.3%. The estimated logistic function indicates, however, that diffusion had

[3] Borrower information does not permit identification of ranchers who once adopted, but subsequently dropped, pasture improvement. Hence, the measured price elasticity is probably underestimated.

[4] The coefficients on inflation and the adjustment index displayed the expected signs, assuming that inflation would reduce the real interest rate on partially adjusted loans and that an increase in the adjustment index would increase the real interest rate ranchers expected to pay.

[5] The length of the diffusion period for improved pastures in Uruguay (twenty years) is similar to those of other technologies in other situations (Mansfield 1968).

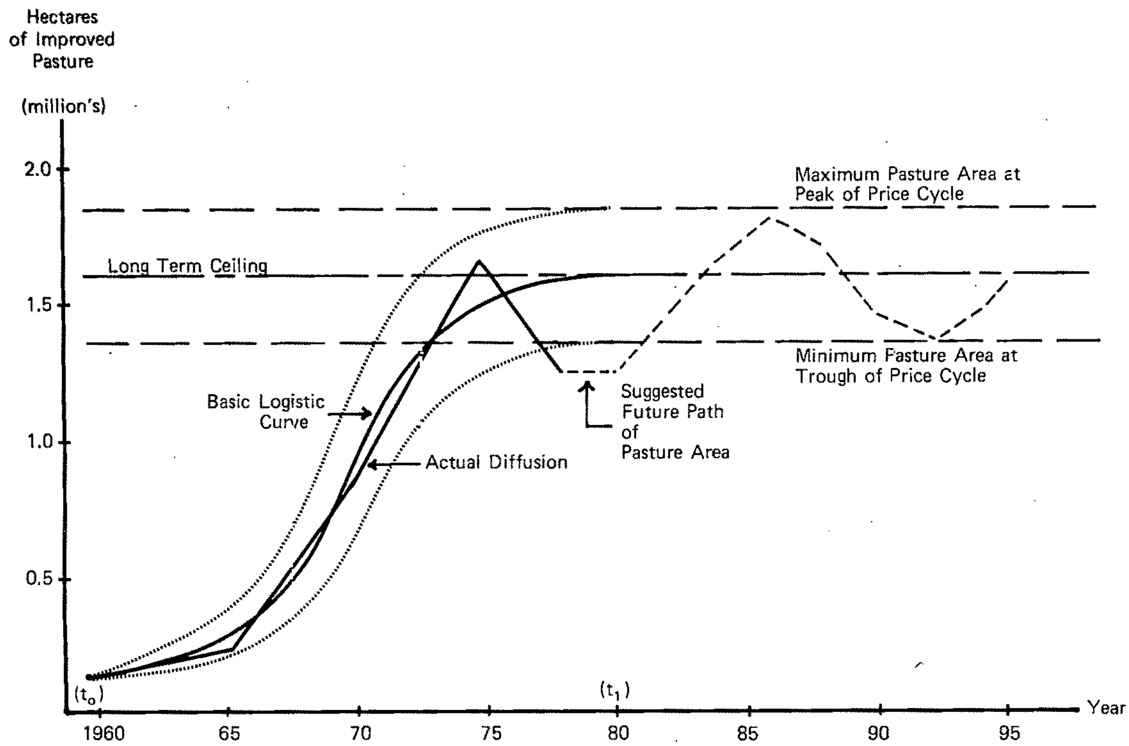

Figure 1. Stylized price response during diffusion and thereafter

not ended by 1975, having reached only about 90% of its final ceiling. Accordingly, the area planted to improved pastures should have been about 12% of total pasture area (0.9 × 13.3). This figure is close to the 11.5% actually recorded. Similarly, the low prices of 1975–77 would have lowered the ceiling to about 10.5% of total area. By 1978, however, the diffusion should have reached more than 95% of the (mean price) ceiling. Thus, the area dedicated to improved pastures would have been about 10% of total pasture area, close to that actually observed, 9%.

Assuming that prices cycle the same mean observed during the last twenty years, the area planted will average 11.5% over the price cycle. Because this ceiling already has been reached, no further permanent diffusion is expected. However, when prices rise to their peak, about 50% above the mean price, the total area planted should rise to about 13%. When prices decline to the trough, the area should decline to about 10%. However, if either international demand for Uruguayan beef or government policy determining the relation between domestic and international prices are altered, the "permanent" ceiling could be changed.

The Underlying Causes of Limited Improved Pasture Diffusion

Farm level information also was sought to explain why some producers have not adopted, and why adopters usually have planted, improved pastures on only a small proportion of their ranches. The evidence is fairly clear on two major issues (Jarvis 1980). First, about one-third of Uruguay's ranchers have not adopted because currently available fertilized grass-legume pastures do not thrive under some soil and climactic conditions. Second, improved pastures are used sparingly even on ranches where adoption has occurred because their marginal profitability declines for three reasons: (*a*) the impact of the pastures on total beef output varies by season and by the type of animal fed (under current conditions, improved pastures are profitable when planted principally to ease the winter forage shortage); (*b*) as a ranch's area of improved pastures is increased, management becomes more complex; and (*c*) after the improved area reaches about 20%–25%, forage is wasted during seasons of abundant production because existing herds cannot consume it, and it is not profitable to harvest and store it.

Technological Improvements and the Logistic Curve

Over time, refinements have been made in the availability and management of Uruguayan technology, resulting in some upward shift in improved pasture profitability. These refinements surely have extended the diffusion of improved pasture, though it is difficult to measure their effects with the data available. Unless similar but distinct technologies can be identified, we cannot determine when the ceiling for each is reached. Accordingly, the observed diffusion path will be an aggregate for a group of technologies which appear unique but are developed and introduced serially. The shape of the aggregate diffusion path will reflect the heterogeneity of soils, climate, and producers, plus the timing of new advances. In Uruguay, most of the important technological advances were made before 1966. Thus, the diffusion path probably has not yet been seriously affected. However, any major technological improvement could result in additional diffusion, which itself could be logistic in nature.

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The Supply and Demand of Marketing Contracts under Risk

Steven T. Buccola

Bernoullian decision theory is used to characterize a firm's willingness to purchase or sell a good under contract. Contract supply and demand functions are then specified in which willingness to contract is related to contract-pricing provisions, to decision maker risk aversion, to open market opportunities, and to other factors. On the basis of these relations, a theory of exchange is proposed which incorporates decision making under risk. Implications of the analysis differ by contract type; cost-plus and fixed-price forward deliverable contracts are emphasized.

Key words: exchange, expected utility, forward deliverable contracts, marketing contracts, risk.

Agricultural economists have made wide use of programming techniques to generate risk-efficient farm plans and marketing portfolios (Ward and Fletcher, Anderson, Barry and Willmann, Schurle and Erven). In several studies, the additional step has been taken of employing decision maker utility functions to generate maximum-expected-utility solutions (Eidman, Dean, Carter; Attanasi and Karlinger).

A principal limitation of both approaches is that risk-efficient portfolios and their probability density functions may change dramatically as parameters of alternative farm enterprises or marketing options are varied (Buccola and French 1978). For example, new risk-efficient frontiers must be developed each time the mean return of an individual marketing or production option is revised. Any normative economic analysis requires redevelopment of optimum solutions once important parameters are varied. In neoclassical theory, entrepreneurs identify new maximum-profit output or input levels in response to each new output or input price, and these responses are incorporated into a broader theory of exchange. No such theory has been elaborated for decision makers who wish to select portfolios of exchange arrangements that maximize Bernoullian expected utility, although related work has been conducted by Holthausen, Hildreth (1974), and Buccola and French (1979).

In this paper, aspects of such a theory of exchange under risk are investigated. The analysis focuses on a buyer and seller of a fixed quantity of a single commodity, each of whom seeks to allocate his purchases (or sales) between two exchange arrangements so as to maximize his own expected utility. An example is that of a farmer who is faced at planting time with allocating his eventual product sales between forward deliverable contracts and open market transactions. A first handler may face a similar problem in allocating his eventual raw product purchases.

The Seller

Consider first a firm which plans to produce A units of a good; it has the choice of selling some of these units under marketing contract and some on the open market. The contract may take numerous forms. A wide class of marketing contract arrangements may be defined by expressing the price clause of the contract as a price base B and an associated contract price parameter k. For instance, the price received under a cost-plus arrangement would be kB, where B is the seller's per unit variable cost of production (a random variable) and $k > 1$ is some positive factor. In a fixed-price arrangement, both k and B would

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be stated constants. Defining M as the open market price, V as the proportion of A sold under contract, C as per unit variable costs, and F as per unit fixed costs, the seller's profit π_s is

$$(1)\quad \pi_s = A[VkB + (1 - V)M - C - F],$$

where $0 \leq V \leq 1$.

The form of the expected utility function associated with (1) depends upon the form of the decision maker's Bernoullian utility function for profit. A variety of functional forms has been proposed. Unfortunately none of those exhibiting the desirable property of decreasing absolute risk aversion permit an expected utility formulation that can be maximized explicitly (Lin and Chang, Keeney and Raiffa).[1] This analysis is confined to the negative exponential function $U = -\exp[-\lambda\pi]$, $\lambda > 0$, with constant absolute risk-aversion coefficient λ. Freund has shown that if returns π are normally distributed, the expected utility function associated with negative exponential utility may be maximized by maximizing the certainty equivalent $Z = E(\pi) - (\lambda/2)\text{var}(\pi)$ if $\lambda > 0$.

In the following, expected values are denoted by E_i, variances by S_i^2, and covariances by S_{ij}. Assuming that the variance of fixed costs F is zero, the certainty equivalent Z of risky prospect (1) is

$$(2)\quad \begin{aligned} Z = {} & A[a + (-E_m + E_bk)V] \\ & - (\lambda/2)A^2[b + (2c + 2dk)V \\ & + (S_m^2 - 2S_{bm}k + S_b^2k^2)V^2)], \end{aligned}$$

where

$$\begin{aligned} a &= E_m - E_c - F \lesseqgtr 0, \\ b &= S_m^2 + S_c^2 - 2S_{mc} \geq 0, \\ c &= -S_m^2 + S_{mc} \gtreqless 0, \\ d &= S_{bm} - S_{bc} \gtreqless 0. \end{aligned}$$

The portfolio proportion V^* at which certainty equivalent Z reaches an extreme value is

$$(3)\quad V^* = \frac{(-E_m + E_bk) - \lambda A(c + dk)}{\lambda A(S_m^2 - 2S_{bm}k + S_b^2k^2)},$$

where $0 < V^* < 1$. Second-order conditions for a maximum are satisfied because

$$\partial^2Z/\partial V^2 = -\lambda A^2(S_m^2 - 2S_{bm}k - S_b^2k^2)$$

is nonpositive regardless of the value of k. The seller would maximize expected utility if he could sell AV^* of his product under the contract arrangement and $A(1 - V^*)$ at the open market price.

Supply of Marketing Contracts

Proportion V^* may be interpreted as the seller's willingness to sell under contract. It increases with the expected return (E_bk) and decreases with the variance of return ($S_b^2k^2$) of the contract. In addition, willingness to contract is a function of price parameter k, risk-aversion coefficient λ, and total sale quantity A. The seller's contract supply curve is the set of proportions V^* that is generated as price parameter k varies and λ and A are held fixed. The slope of this curve is a complex function of k. Better insight into the behavior of the supply curve is provided by analysis of the responsiveness of V^* to the risk-aversion parameter λ. For this purpose, it is useful to define the "equi-mean" value of price parameter k as that value which equates the expected values of the contract and market prices; that is, it is the value of k for which $E_bk = E_m$, or $k = E_m/E_b$.

If k is below equi-mean (and thus the marketing contract offers lower return than the open market), increases in the risk-aversion coefficient increase the seller's relative preference for the contract. If k is above equi-mean, increases in risk aversion decrease relative preference for the contract. At the equi-mean point, risk aversion has no impact on such preferences. To prove this, note that the partial derivative of V^*, the optimal contract share of the portfolio, with respect to λ is

$$(4)\quad \partial V^*/\partial\lambda = \frac{E_m - E_bk}{\lambda^2A(S_m^2 - 2S_{bm}k + S_b^2k^2)}.$$

Where $k < E_m/E_b$, expression (4) is positive (since the denominator is positive), meaning that V^* rises with λ. Where $k > E_m/E_b$, V^* falls with increasing λ. On the other hand, if $k = E_m/E_b$, the value of (4) is always zero.

As a consequence, increases in risk aversion cause the contract supply curve to rotate counterclockwise around the contract price parameter k's equi-mean value. That is, increasing risk aversion decreases the sensitivity with which optimal portfolios react to changes in the price parameter. The greater the positive or the smaller the negative corre-

[1] An example is the Bernoullian utility function recommended by Hildreth (1977), $U = ax - \theta\exp[-\lambda x]$ where U is utility, x is income, and $a, \theta, \lambda > 0$. If $x \sim N(\mu, \sigma^2)$, expected utility is $EU = a\mu - \theta\exp[-\lambda^2\sigma^2/2 - \lambda\mu]$, which feasibly may be maximized only with numerical techniques. The constant elasticity family of functions recommended by Tsaing poses similar problems.

lation between the contract price base and the open market price, the greater is this rotation response to risk-aversion changes. It is easily shown that increases in the total quantity A of product sold also rotate the seller's contract supply curve counterclockwise around parameter k's equi-mean value.[2]

Cost-Plus and Fixed-Price Contracts

If a cost-plus contract is envisioned, E_b in (4) is identical to E_c, the expected variable cost of production; furthermore $S_{bm} \equiv S_{cm}$, and $S_b^2 \equiv S_c^2$. In this case, (4) may be interpreted as saying that increasing risk aversion increases, has no effect on, or decreases preference for the cost-plus contract according as the expected cost-plus price E_bk falls short of, equals, or exceeds the expected market price E_m.

If the marketing contract considered is instead a fixed price per unit, the optimal contract proportion V^* assumes an especially simple form. Because the fixed price, E_bk, is a legally or morally binding price, its variance $(S_b^2k^2)$ and all covariances involving the contract price ($S_{bm}k$ and $S_{bc}k$) are zero. Hence (3) is reduced to

$$(3)' \qquad V^* = \frac{-E_m + E_bk - \lambda Ac}{\lambda AS_m^2} = 1 + \frac{-E_m + E_bk}{\lambda AS_m^2} - \frac{S_{mc}}{S_m^2}.$$

The slope of this supply function, that is the impact of a marginal increase in the fixed price on the optimal contract proportion, is

$$(5) \qquad \partial V^*/\partial(E_bk) = \frac{1}{\lambda AS_m^2},$$

which is positive and invariant with respect to the fixed price level. Similarly, the impact of increasing risk aversion on the optimally contracted proportion is

$$(4)' \qquad \partial V^*/\partial\lambda = \frac{E_m - E_bk}{\lambda^2 AS_m^2} \gtreqless 0.$$

Fixed-price contracts have received special attention in the literature because farmers frequently have the choice at planting time of forward contracting a portion of their crop for a fixed and known price; the remainder can be sold after harvest at the prevailing market price which, at planting time, is a random variable (Barry and Willmann; Eidman, Dean, Carter). Examination of (3)', (5), and (4)' provides several important insights for risk-averse farmers with exponential utility, facing normally distributed prices and costs, and considering fixed-price contracts.

(*a*) If the covariance S_{mc} between market prices and variable production costs in (3)' is near zero, the proportion of acreage optimally allocated to a fixed-price contract is less than 100% only when the fixed price is less than the expected market price.

(*b*) As the perceived variance of open market prices increases, the proportion of acreage optimally allocated to fixed-price contracts approaches 100%.

(*c*) The effect of increasingly positive association between open market prices and production costs is to increase optimal preference for open market sales. When market prices and production costs are positively associated, even extremely risk-averse farmers will prefer a combination of fixed-price and market price sales.

The Buyer

The buyer situation comparable to the above is that in which a processing firm wishes to purchase A units of a good, transform them in some way, and resell them. The buyer has the choice of dividing its acquisitions between contract and open market purchases. Defining, on a raw-product-equivalent basis, R as the per unit resale price, T as the per unit variable cost of transformation, G as the per unit fixed cost of transformation, W as the proportion of goods purchased by contract, and all other symbols as previously noted, the buyer's profit π_b may be represented as

$$(6) \quad \pi_b = A[R - WkB - (1 - W)M - T - G],$$

where $0 \leq W \leq 1$.

If prices and yields are normally distributed and the buyer has exponential profit utility with absolute risk-aversion coefficient γ, the certainty-equivalent function Y corresponding to (6) is

$$(7) \quad Y = A[j + (E_m - E_bk)W] - (\gamma/2)A^2[f + (2g + 2hk)W + (S_m^2 - 2S_{bm}k + S_b^2k^2)W^2],$$

[2] This is seen by analysis of the partial derivative $\partial V^*/\partial A = (E_m - E_bk)/\lambda A^2(S_m^2 - 2S_{bm}k + S_b^2k^2)$.

where

$$j = E_r - E_m - E_t - G \lesseqgtr 0,$$
$$f = S_r^2 + S_m^2 + S_t^2 - 2(S_{mr} + S_{rt} - S_{mt}) \geq 0,$$
$$g = -S_m^2 + S_{mr} - S_{mt} \gtreqless 0,$$
$$h = -S_{br} + S_{bm} + S_{bt} \gtreqless 0.$$

The portfolio proportion W^* at which the buyer's certainty equivalent, and thus his expected utility, reach an extreme value is

$$(8) \quad W^* = \frac{(E_m - E_bk) - \gamma A(g + hk)}{\gamma A(S_m^2 - 2S_{bm}k + S_b^2k^2)}.$$

This again represents a maximum because

$$\partial^2 Y/\partial W^2 = -\gamma A^2(S_m^2 - 2S_{bm}k + S_b^2k^2) \leq 0.$$

Demand for Marketing Contracts

Proportion W^* is the buyer's demand for purchases under contract; the relation between W^* and k is the buyer's contract demand curve. Propositions analogous to those proven for the seller can also be proven for the buyer. For example, if k is below the equi-mean point (and thus the contract price offers higher expected return than the open market), increases in risk aversion decrease the buyer's relative preference for contract purchases. If k is above equi-mean, higher risk aversion increases relative preference for contract purchases. At the equi-mean point, risk aversion has no impact on optimal portfolio preference. These relations, which are opposite in sign to those holding for sellers, are characterized by the partial of W^* with respect to risk-aversion coefficient γ:

$$(9) \; \partial W^*/\partial\gamma = \frac{-E_m + E_bk}{\gamma^2 A(S_m^2 - 2S_{bm}k + S_b^2k^2)}.$$

Equation (9) is negative, positive, or zero according as k falls short of, exceeds, or equals E_m/E_b, the equi-mean value. Thus the buyer's contract demand curve rotates clockwise around the equi-mean value E_m/E_b as absolute risk-aversion coefficient γ rises.

Fixed-Price Contracts

In the special case of a fixed-price contract, the demand curve is always negatively sloped and linear. This holds because when $S_b^2 = 0$, (8) is reduced to

$$(8)' \quad W^* = \frac{E_m - E_bk - \gamma Ag}{\gamma A S_m^2} = 1 + \frac{E_m - E_bk}{\gamma A S_m^2} - \frac{(S_{mr} - S_{mt})}{S_m^2},$$

the slope of which is

$$(10) \quad \partial W^*/\partial(E_bk) = \frac{-1}{\gamma A S_m^2} < 0,$$

a constant with respect to the initial level of fixed price E_bk. Implications of (10) are that the buyer's demand for fixed-price purchases becomes perfectly inelastic with respect to changes in the fixed price as the absolute risk-aversion coefficient, the total quantity sought for purchase, or the perceived variance of spot market prices becomes large. In (8)', covariance S_{mt} between raw product market prices and transformation costs is normally small; but the association S_{mr} between raw product and finished product market prices is often strongly positive. Under these conditions the third term in (8)' will have negative effect, so that buyers with high risk aversion will always prefer some spot market purchases. Note that when the contract price is fixed and risk-aversion coefficients of buyer and seller are identical, slopes of the supply and demand curves are equal and opposite in sign (compare [5] and [10]).[3]

Equilibrium

It is instructive to define conditions under which seller and buyer agree on the portfolio proportions they would allocate to contract transactions. Assume the two traders have equal bargaining power and identical subjective probability distributions of revenues and costs. Then the contract price parameter k_e for which trade agreement is reached is that value of k for which V^* in (3) equals W^* in (8). Equating the right-hand sides of (3) and (8), dividing each by $\alpha = \gamma/\lambda$, then cross-multiplying and cancelling terms, this is equivalent to the value of k for which

$$\gamma A[(E_m - E_bk) - \gamma A(g + hk)] = \alpha\gamma A[(-E_m + R_bk) - \lambda A(c + dk)].$$

[3] For cost-plus contracts, the slopes are approximately equal under these conditions because terms $\lambda A(c + dk)$ and $\gamma A(g + hk)$ in (3) and (8) are small relative to $(E_m - E_bk)$. In the absence of the two former terms, V^* would be identical to $-W^*$, so that $\partial V^*/\partial k$ would equal $-\partial W^*/\partial k$.

Regrouping terms, solving for equilibrium value k_e, and substituting for g, c, h, and d,

$$(11)\ k_e = \frac{E_m(1+\alpha) - \gamma A(S_{mr} - S_{mt} - S_{mc})}{E_b(1+\alpha) - \gamma A(S_{br} - S_{bt} - S_{bc})}.$$

The equilibrium parameter increases with the expected market price and with the covariances between market price and production costs (S_{mt} and S_{mc}). It decreases with increases in the covariance between raw and final product market prices (S_{mr}).

If a cost-plus contract is considered, the contract price basis B is identical to C (per unit variable cost), so that $S_{bc} \equiv S_c^2 > 0$. In many situations, furthermore, covariances $S_{br} \equiv S_{cr}$, $S_{bt} \equiv S_{ct}$, S_{mt}, and S_{mc} are near zero. Making these assumptions, (11) reduces to

$$(11)' \qquad k_e = \frac{E_m(1+\alpha) - \gamma A S_{mr}}{E_c(1+\alpha) + \gamma A S_c^2}.$$

Hence, for the frequent, but not universal, case in which raw product and finished product market prices are positively correlated ($S_{mr} > 0$), k_e is less than E_m/E_c. That is, the expected equilibrium cost-plus price, $E_c k_e$, is less than the expected market price E_m.

If a fixed-price contract is considered, B is nonstochastic and $S_{br} = S_{bt} = S_{bc} = 0$. Equation (11) then reduces, in cross-multiplied form, to

$$(11)'' \quad E_b k_e = E_m - \gamma A(S_{mr} - S_{mt} - S_{mc})/(1+\alpha).$$

The equilibrium fixed contract price, $E_b k_e$, is less than the expected market price E_m if, as would be true in many cases, the covariance S_{mr} between raw product and finished product market prices is algebraically greater than the sum $(S_{mt} + S_{mc})$ of covariances between raw product market price and production costs. In general, the equilibrium fixed price depends on the relative magnitudes S_{mr} and $(S_{mt} + S_{mc})$ as well as on α. If seller and buyer are risk neutral ($\gamma = \alpha = 0$), or if all prices and costs are uncorrelated ($S_{mr} = S_{mt} = S_{mc} = 0$), the equilibrium fixed price equals the expected market price. In the latter case, all goods are sold by fixed-price contract because V^* in (3)' and W^* in (8)' equal one.

Applications

Data drawn from contract negotiations at planting time between a California tomato processor and producers are now used to illustrate some of the above relationships.[4]

Cost-Plus

In the first application (figure 1), producer and processor each select a marketing portfolio consisting of some combination of cost-plus contracts and open market transactions. Thus, V^* represents the proportion of total acreage the tomato seller optimally allocates to cost-plus sales, and W^*, the proportion of total acreage the tomato buyer optimally allocates to cost-plus purchases. Quantities $(1 - V^*)$ and $(1 - W^*)$ represent the proportions of total acreage optimally allocated by each to market price sales or purchases. By (3) and (8), proportions V^* and W^* are functions of markup parameter k.

The first set of supply and demand curves (solid lines) in figure 1 were derived using absolute risk-aversion coefficients actually estimated from utility responses of a tomato producer and tomato processor representa-

[4] The modeled producer had 1,333 acres of tomatoes to sell on contract to a single processor, and the processor sought to purchase by contract a total of 30,000 acres of tomatoes from all growers. Because total buyer volume exceeded total seller volume, it was assumed that the buyer treated all sellers alike from the standpoint of contract negotiations. Means, variances, and covariances were estimated from historical price and cost series and from decision makers' subjective probabilities. Chi-square tests of the null hypotheses that each price and cost variable was normally distributed did not indicate any non-normality at the 5% confidence level (Buccola and French 1978).

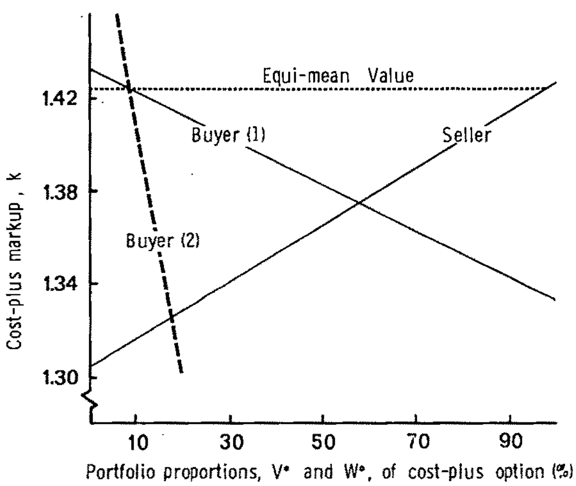

Figure 1. Equilibrium portfolio agreement between seller and buyer when the alternative marketing options are cost-plus and market price

tive. (They were $\lambda = .0012$ for the producer and $\gamma = .000045$ for the processor, where profit is expressed in \$1,000 units.) Increases in cost-plus markup k increase the proportions of total acreage offered by the producer on a cost-plus contract basis and decrease the proportions of total acreage sought by the processor on a cost-plus contract basis. Despite the complex form of functions (3) and (8), each is relatively linear in this example. Optimal portfolio proportions of buyer and seller agree only where $k = 1.374$, that is, where the cost-plus contract pays 137% of variable production costs. This is considerably below the equi-mean value (1.422) where cost-plus and market price formulas have equal expected value. The dotted line in figure 1 results when the processor-buyer's risk-aversion coefficient is increased: the demand curve rotates clockwise around equi-mean value $k = 1.422$, and the equilibrium value of k (that is k_e) falls to 1.325.

Fixed-Price

In the second application (figure 2), the producer optimally allocates a proportion V^* of his tomato acreage to fixed-price-per-ton forward deliverable contracts and the remaining proportion $(1 - V^*)$ to open market sales. The processor optimally allocates a proportion W^* of the tomato acreage he contracts to fixed-price terms and the remainder $(1 - W^*)$ to open market purchases. Because acres rather than tons are contracted in this instance, some

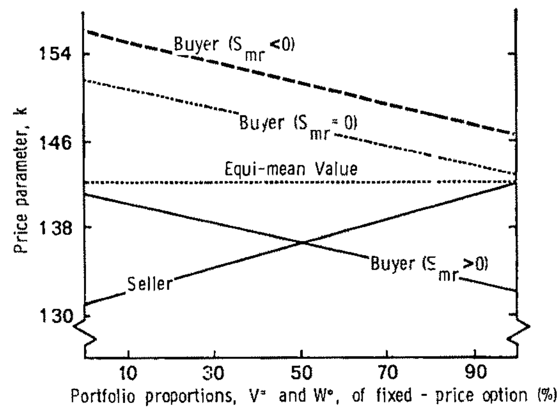

Figure 2. Equilibrium portfolio agreement between seller and buyer when the alternative marketing options are fixed price and market price

yield risk remains in the fixed-price contract, and it is not strictly true that $S_b{}^2 = S_{bm} = S_{bc} = 0$. However, the estimated coefficient of variation of tomato yields was small (less than 3%) and considered negligible for our purposes. The fixed price, represented by $E_b k$, is here varied by varying k and holding E_b constant, such that $E_m/E_b = 1.422$ (as in figure 1). Thus, a forward contract's fixed price per ton equalled the expected tomato market price per ton when k equalled 1.422.

Three situations are depicted in figure 2. In the first (solid lines), the covariance between market prices of raw tomatoes and processed tomato products (S_{mr}) was as empirically estimated. Because this covariance was positive (correlation = .514) and greater than covariance sum ($S_{mt} + S_{mc}$) in (11)′, the equilibrium fixed-price level $E_b k_e$ was less than expected market value E_m. In the second situation, covariance S_{mr} was set at zero, with the result that the processor-buyer's demand curve, equation (8)′, shifted to the right. Quantity $\gamma A(S_{mt} + S_{mc})$ in (11)′ was a relatively small number in this example; thus, in the new equilibrium solution the fixed tomato price approximately equalled the expected market value of tomatoes. For the third situation, covariance S_{mr} was assigned an arbitrary negative value (correlation = −.179), the buyer demand curve shifted further to the right, and no equilibrium solution was achieved. Further buyer-seller negotiations would, if conducted on an equal-market-power basis, result in a fixed price somewhere above the expected market value.

Conclusions

Explicit representation of decision makers' expected utility functions provides important insights into rational marketing portfolio selection. In general, a decision maker's demand for each marketing alternative is a function of the contract price parameters specified. Quantities that sellers wish to trade under each alternative may be expressed as positively sloped contract supply curves. Quantities that buyers wish to trade may be expressed as negatively sloped contract demand curves. Mutually agreeable marketing portfolios then can be determined using standard equilibrium methods.

The analysis shows that, among individuals with exponential utility, sensitivity of optimal marketing portfolios to changes in contract price parameters diminishes as risk aversion rises. Negotiated equilibrium levels of such parameters as cost-plus markups or fixed prices depend critically upon perceived covariances between revenue and cost variables in buyers' and sellers' profit functions. Only in special cases, such as when decision makers are risk neutral or covariances are zero, could one anticipate that all negotiated price formulas would have equal expected values.

An important application of this analysis to farmer market contracting is where farmers are faced with the choice at planting time between sales at fixed-price, forward deliverable contracts and sales at eventual open market prices. An example suggests that mutually agreeable fixed prices for forward deliverable contracts are highly sensitive to the covariance that (*a*) the buyer perceives between raw product and finished product prices, and (*b*) the seller perceives between raw product prices and farm production costs. Other than by reference to these covariances, and to the risk aversion of the buyer relative to the seller, it is impossible to determine whether fixed prices negotiated on an equal-market-power basis will be above, equal to, or below expected market prices.

The present framework does not permit sellers and buyers to select the stage in the production process at which it would be optimal to contract. However, given its static limitations, the framework is applicable to a wide variety of pricing arrangements between sellers and buyers, including use of futures contracts. Its principal value is to extend the theory of exchange to cases in which the outcomes of marketing arrangements are not known with certainty.

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An Interval Approach to Measuring Decision Maker Preferences

Robert P. King and Lindon J. Robison

A method for constructing interval measurements of decision makers' absolute risk-aversion functions is presented. Under this new procedure, the form of the absolute risk-aversion function is not restricted, and the precision of the interval measurement can be determined by the analyst. Interval measurements are used with the criterion of stochastic dominance with respect to a function to order uncertain choices. An empirical test shows that interval measurements exclude preferred choices from consideration less often than do single-valued utility functions and are more discriminating than first- and second-degree stochastic dominance.

Key words: preference measurement, risk aversion, stochastic dominance, uncertainty.

Agricultural producers operate in a highly uncertain decision-making environment. Recognizing this, agricultural economists have made considerable progress in incorporating uncertainty into the framework for decision analysis (e.g., Halter and Dean; Dillon; Anderson, Dillon, Hardaker). These advances often have proved difficult to implement in practice, however, and in many instances the impact of uncertainty is either ignored or treated in a manner that is difficult to reconcile with theory.

The expected-utility hypothesis is the basis for much of the theory of decision making under uncertainty. It states that choices made under uncertainty are affected by the decision maker's preferences and expectations, and it provides a general decision rule—expected utility maximization—which integrates information on these two factors to identify preferred choices. Despite its wide acceptance as a theoretical tool, important operational problems make the expected-utility hypothesis difficult to apply in the analysis of actual decisions. One such problem is that use of the expected-utility hypothesis requires explicit information about the decision maker's preferences. Unfortunately, as Young et al. note, preferences are difficult to measure accurately enough to permit the reliable evaluation of alternative choices.

In this paper, a new method for measuring preferences is introduced. This method overcomes many of the problems stemming from the use of existing procedures and can be a useful tool in applied decision analyses. In the sections which follow, currently used techniques for measuring and representing preferences are first reviewed. A recently developed criterion for ordering uncertain choices, stochastic dominance with respect to a function (Meyer 1977a), is then introduced, and a preference measurement technique designed to be used in conjunction with this criterion is presented. Procedures for implementing this new method are then described, and the results of an empirical test of its effectiveness are presented.

Existing Techniques for Measuring and Representing Preferences

The most direct way to measure preferences is to derive the decision maker's utility function. Utility functions relate the outcomes of choices to single-valued indices of desirability. As such, they are exact representations of preferences. Because of shortcomings in the design of preference elicitation interviews (Officer and Halter, Binswanger), problems in

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statistical estimation (Knowles), and respondents' own lack of precise knowledge about their preferences (Zadeh), however, utility functions also tend to be unreliable. Despite such problems, a utility function, once estimated, is usually treated as an exact representation of preferences when alternative choices are ordered. Any absolute difference in the expected utilities of two choices is taken as a clear indication that one is preferred to the other. As a result, inaccuracies in an elicited utility function can cause the rejection of a choice actually preferred by the decision maker.

Imprecision in the measurement of decision maker preferences can be recognized explicitly be using an efficiency criterion rather than a single-valued utility function to order alternatives. An efficiency criterion is a decision rule that provides a partial ordering of choices for decision makers whose preferences conform to a specified set of conditions. For example, first- and second-degree stochastic dominance (Hadar and Russell; Hanoch and Levy) are among the simplest efficiency criteria. First-degree stochastic dominance holds for all decision makers who prefer more to less—i.e., for all those who have positive marginal utility for the performance measure being considered. Second-degree stochastic dominance places an additional restriction on preferences. It requires that the decision maker's marginal utility be both positive and decreasing. Other familiar efficiency criteria, such as mean-variance efficiency (Markowitz) and mean-absolute deviation efficiency (Hazell), impose alternative sets of restrictions on preferences and/or on the form of the probability distributions of the performance measure.

The use of an efficiency criterion to order choices is, in many respects, preferable to the use of a single-valued utility function. No direct preference measurements need be made, and, if enough alternatives can be eliminated, a final choice can be made by direct comparison of the outcome distributions of those that remain. Unfortunately, the most commonly used efficiency criteria have several serious shortcomings which limit their usefulness. First, they often are not discriminating enough. In an application of second-degree stochastic dominance by Anderson, for example, twenty of forty-eight randomly generated farm plans were in the efficient set. Furthermore, the restrictions on preferences imposed by an efficiency criterion may be difficult to reconcile with theoretical and empirical findings. Again focusing attention on second-degree stochastic dominance, strong theoretical arguments have been made for the possibility of increasing marginal utility over certain outcome ranges (Friedman and Savage; Kahneman and Tversky), and empirical evidence indicates that agricultural producers do at times exhibit increasing marginal utility (Officer and Halter; Conklin, Baquet, Halter; Dillon and Scandizzo; Halter and Mason). Finally, unrealistic assumptions also may be imposed on probability distributions. Under mean-variance efficiency, perhaps the most widely used efficiency criterion in the agricultural economics literature, outcome distributions are assumed to be normal. This assumption is highly suspect, given the skewed nature of price and yield distributions in agriculture.

There is a need, then, for efficiency criteria which are both more flexible and more discriminating than those described above. Furthermore, there is a need for preference measurement techniques which, though less precise than those used to construct single-valued utility functions, provide an empirically based representation of a decision maker's preferences. In the two sections which follow, a more powerful efficiency criterion, stochastic dominance with respect to a function (Meyer 1977a), is introduced, and a preference measurement technique designed to be used in conjunction with this criterion is presented.

Stochastic Dominance with Respect to a Function

Stochastic dominance with respect to a function is an evaluative criterion which orders uncertain choices for decision makers whose absolute risk-aversion functions lie within specified lower and upper bounds. The absolute risk-aversion function (Arrow, Pratt), $r(y)$, is defined by the expression:

$$r(y) = -u''(y)/u'(y), \tag{1}$$

where $u'(y)$ and $u''(y)$ are the first and second derivatives of a von Neumann-Morgenstern utility function $u(y)$. In the most abstract terms, values of the absolute risk-aversion function are simply local measures of the degree of concavity or convexity of a utility function. As such, they also serve as indicators of the extent to which a decision maker

is risk-averse or risk-loving. Perhaps the most important property of the absolute risk-aversion function, however, is that it is a unique measure of preferences, while a utility function is unique only to a positive linear transformation.[1] In effect, then, upper and lower bounds on a decision maker's absolute risk-aversion function define an interval representation of preferences. Stochastic dominance with respect to a function orders choices on the basis of such a representation.

More formally stated, stochastic dominance with respect to a function is a criterion which establishes necessary and sufficient conditions for the distribution of outcomes defined by the cumulative distribution function $F(y)$ to be preferred to that defined by the cumulative distribution function $G(y)$ by all individuals whose absolute risk-aversion functions lie everywhere between lower and upper bounds $r_1(y)$ and $r_2(y)$. As developed by Meyer (1977a), the solution procedure requires the identification of a utility function $u_0(y)$ which minimizes

$$\int_{-\infty}^{\infty} [G(y) - F(y)]u'(y)dy, \tag{2}$$

subject to the constraint,

$$r_1(y) \leq -u''(y)/u'(y) \leq r_2(y), \tag{3}$$

for all y. The expression in equation (2) is equal to the difference between the expected utilities of outcome distributions $F(y)$ and $G(y)$. If, for a given class of decision makers, the minimum of this difference is positive, $F(y)$ is unanimously preferred to $G(y)$, since this implies that the expected utility of $F(y)$ is always greater than that of $G(y)$. If the minimum is zero, it is possible for an individual in the relevant class of decision makers to be indifferent between the two alternatives, and they cannot be ordered. Should the minimum be negative, $F(y)$ cannot be said to be unanimously preferred to $G(y)$. In this case, the expression

$$\int_{-\infty}^{\infty} [F(y) - G(y)]u'(y)dy \tag{4}$$

must then be minimized subject to equation (3) to determine whether $G(y)$ is unanimously preferred to $F(y)$. It should be noted that a complete ordering is not ensured by the criterion. It is possible for the minimum of both equations (2) and (4) to be negative, which implies that neither distribution is unanimously preferred by the class of decision makers being considered.

Meyer uses optimal control techniques to derive the necessary and sufficient conditions for the solution of this problem. These conditions define a rule for determining the absolute risk-aversion function of the utility function which minimizes equation (2)—a rule can be applied if the relatively unrestrictive assumption that $[G(y) - F(y)]$ changes sign a finite number of times is met. Details of the solution technique are given in Meyer (1977a), and an example showing how the solution can be implemented is given in King and Robison (1981).

The major advantage of this criterion is that it imposes no restrictions on the width or shape of the relevant risk-aversion interval. The lower and upper bound absolute risk-aversion functions need not be constants and can be placed anywhere in risk-aversion space. Less flexible efficiency criteria, such as first- and second-degree stochastic dominance, can be viewed as special cases of this more general criterion. The requirement under first-degree stochastic dominance that marginal utility be positive places no restrictions on the decision maker's absolute risk-aversion function—i.e., $r_1(y) = -\infty$ and $r_2(y) = \infty$ for all possible values of y. The requirement under second degree stochastic dominance that marginal utility be decreasing as well as positive, on the other hand, implies that $r_1(y) = 0$ and $r_2(y) = \infty$ for all values of y.

A simple example will help to demonstrate the advantages of stochastic dominance with respect to a function. Consider the three outcome distributions in table 1. Let them represent probability distributions of net farm income levels associated with three distinct,

Table 1. Probability Distributions of Net Farm Income for Three Hypothetical Farm Plans

A	B	C
	($)	
9,950[a]	10,000	10,100
12,000	12,000	10,100
13,075	13,000	10,100

[a] Each element of each distribution has a one-third probability of occurring.

[1] Because a utility function is unique only to a positive linear transformation, $u(y)$ and

$$u^*(y) = a + bu(y), b > 0$$

are strategically equivalent, though perhaps highly dissimilar, utility functions. The absolute risk-aversion functions of these two utility functions, however, are identical.

hypothetical farm plans. Assume that a single-valued utility function of the following form has been elicited for an agricultural producer:

$$u(y) = -e^{-.0003y}, \tag{5}$$

where y is net farm income and .0003 is an estimated constant value of the decision maker's absolute risk-aversion function. This value falls within the range suggested by Freund. Using this utility function and the criterion of expected utility maximization to order the three farm plans, B is preferred to A, and both A and B are preferred to C. The difference in the expected utilities of plans A and B is quite small, however. Most decision makers would have difficulty choosing between them in an actual decision situation, and many would ask for additional information before selecting one over the other. With strict reliance on the ordering provided by equation (5), however, only plan B would be presented to the decision maker.

Plans A and B cannot be ordered under the criteria of first- and second-degree stochastic dominance. The difficulty decision makers would have in ranking these distributions is recognized, then, under these criteria. Unfortunately, they also fail to order distribution C with respect to either A or B. This is true because the ultimate risk averter, the decision maker who employs a maximin decision rule and so prefers distribution C, is included in the class of decision makers for whom both first and second degree stochastic dominance hold. As a result, nothing is eliminated from consideration.

Finally, if these three distributions are evaluated using stochastic dominance with respect to a function with lower and upper bounds on absolute risk aversion being set at .0001 and .0004, only plans A and B are in the efficient set. Unlike the single-valued utility function, then, this criterion does not require an exact representation of preferences and does not limit the efficient set to a single choice when the ordering of some alternatives may be sensitive to small errors in the measurement of preferences. Unlike other first- and second-degree stochastic dominance, it does not require that fixed restrictions be imposed on the representation of preferences. Rather, because the bounds on absolute risk aversion can be placed anywhere in absolute risk-aversion space and as close together as desired, stochastic dominance with respect to a function can be the basis for a more complete ordering than can be obtained with these criteria.

The problems associated with single-valued utility functions and first- and second-degree stochastic dominance are not particularly serious when only a few choices are involved, as is the case in this example. In situations where the number of possible actions is quite large and some optimization procedure is used to evaluate them, as is typical in farm-planning problems, these shortcomings do become important. In such an analysis one must question the wisdom of presenting the decision maker with a single optimal plan based on unreliable preference measurements, and one must question the value of presenting him with an efficient set of choices containing a very large number of plans. Stochastic dominance with respect to a function has the potential for alleviating these difficulties by allowing the analyst to specify the degree of precision with which preferences are represented.

An Interval Approach to the Measurement of Decision Maker Preferences

Stochastic dominance with respect to a function is a powerful analytical tool. If it is to be used in an applied context, however, an operational procedure for the determination of lower and upper bounds on a decision maker's absolute risk-aversion function is required. Such a procedure is introduced in this section. It uses information revealed by a series of choices between carefully selected distributions to establish lower and upper bounds on an individual's absolute risk-aversion function. The degree of precision with which preferences are measured—i.e., the size of the interval between the lower and upper bound functions—can be specified directly in accordance with the characteristics of the problem under consideration. At one extreme, the interval can be of infinite width; at the other extreme, it can converge to a single line.

The procedure for constructing interval measurements of decision maker preferences is based on the premise that under certain conditions, a choice between two distributions defined over a relatively narrow range of outcome levels divides absolute risk-aversion space over that range into two regions: one consistent with the choice and one inconsistent with it. The properties of the two distribu-

tions determine the level of absolute risk aversion at which the division is made and so define the two regions. The decision maker's preferences, as revealed by his ordering of the two distributions, determine into which of the two regions his level of absolute risk aversion is said to fall. By confronting the decision maker with a series of choices between carefully selected pairs of distributions, the region of absolute risk-aversion space consistent with the decision maker's preferences can repeatedly be divided. With each choice, a portion of that region is shown to be inconsistent with the decision maker's preferences, and the interval measurement for the level of absolute risk aversion is narrowed. The procedure continues until a desired level of accuracy is attained.

The validity of the premise that a choice between two distributions is, under certain conditions, the basis for a division of absolute risk-aversion space into regions consistent and inconsistent with a decision maker's revealed preferences can be demonstrated using a theorem proved by Meyer (1977b, p. 483). The theorem states that, given cumulative distribution functions $F(y)$ and $G(y)$, $F(y)$ is preferred to $G(y)$ by all decision makers more risk-averse than the utility function $k(y)$, and decision makers having utility function $k(y)$ are indifferent between the two distributions only if $G(y)$ is preferred to $F(y)$ by decision makers less risk-averse than $k(y)$.[2] The function $k(y)$, then, can be called a boundary function because it separates a class of decision makers who prefer $F(y)$ from a class who prefer $G(y)$.

If the distributions $F(y)$ and $G(y)$ are defined over a narrow range of outcome levels, and if the decision maker's absolute risk-aversion function can be approximated by a constant value λ over that range, preference for $F(y)$ implies that λ is greater than or equal to the minimum value of the absolute risk aversion associated with $k(y)$. Otherwise, the decision maker would be less risk-averse than $k(y)$, and his choice would be inconsistent with expected utility maximization. Preference for $G(y)$, on the other hand, implies that λ is less than or equal to the maximum value of the absolute risk-aversion function associated with $k(y)$, since $F(y)$ is preferred by all decision makers more risk-averse than $k(y)$. It should be noted that the assumption that a decision maker's absolute risk-aversion function can be adequately approximated by a constant value over a narrow range of outcome levels is critical here. The theorem stated above does not imply that decision makers who prefer $F(y)$ to $G(y)$ are more risk-averse than $k(y)$; nor does it imply that decision makers who prefer $G(y)$ to $F(y)$ are less risk-averse than $k(y)$. With the assumption of constant absolute risk aversion in the neighborhood of a given outcome level, however it can be inferred that decision makers who prefer $F(y)$ to $G(y)$ are not less risk-averse than $k(y)$, and those who prefer $G(y)$ to $F(y)$ are not more risk-averse than $k(y)$.

Boundary functions do not exist for each pair of distributions. For example, one would not exist if one distribution dominates the other by first-degree stochastic dominance. Similarly, the existence of one boundary function does not preclude the existence of others. In general, however, the properties of a boundary function for two distributions are determined by the distributions. By careful selection of distributions, a boundary function can be placed anywhere in risk-aversion space. A series of comparisons can be devised, then, which focuses successively on different regions of absolute risk-aversion space and so allows the repeated reduction of the range of risk-aversion levels consistent with the revealed preferences of a decision maker.

An example will help to illustrate how the procedure works. Consider the three outcome distributions given in figure 1. Each contains

1. Compare distributions 1 and 2, and indicate which one you prefer. If you prefer distribution 1, go to question 3; otherwise, go to question 2. __
2. Compare distributions 1 and 3, and indicate which one you prefer. __
3. Compare distributions 2 and 3, and indicate which one you prefer. __

DISTRIBUTIONS

1[a]	2	3
2,100	1,000	1,750
2,400	2,050	1,950
2,550	2,650	2,500
3,100	3,800	2,750
3,250	3,900	3,950
3,450	5,200	4,000

[a] Each element of each distribution has a one-sixth probability of occurring.

Figure 1. A sample questionnaire for interval preference measurement

[2] Using Pratt's definition of risk aversion in the large, a decision maker with utility function $u(y)$ is more (less) risk-averse than $k(y)$ if the absolute risk-aversion function associated with $u(y)$ is everywhere greater (less) than that associated with $k(y)$.

six possible outcomes said to have equal probability of occurring. Using stochastic efficiency criteria developed by Meyer (1977b), it can be shown that distribution 1 is preferred to distribution 2 by all decision makers whose level of absolute risk aversion is greater than .0005 over the range of outcome levels covered by these two distributions. Distribution 2, on the other hand, is preferred by all decision makers whose level of absolute risk aversion is less than .0001.[3] The two distributions cannot be ordered by unanimous preference over the interval (.0001, .0005), which can be termed a boundary interval in risk-aversion space. The absolute risk-aversion function associated with a boundary function for these two distributions lies everywhere within this interval over the range of outcome levels being considered. If a decision maker prefers distribution 1 to distribution 2, and if it is reasonable to assume that his absolute risk-aversion function can be adequately approximated by a constant value over the range of outcome levels covered by these distributions, it can be concluded that his level of absolute risk aversion over that range is not less than .0001, since there is unanimous preference for distribution 2 by decision makers less risk-averse than .0001. Similarly, if he prefers distribution 2, it can be concluded that his level of absolute risk aversion is not greater than .0005. Therefore, preference for either one of the two distributions identifies a portion of risk-aversion space inconsistent with the choice made.

Boundary intervals also can be identified for distributions 1 and 3 and distributions 2 and 3. For distributions 1 and 3, the interval is (−.0001, .0001), with distribution 3 preferred below the boundary interval and distribution 1 preferred above it. For distributions 2 and 3, the interval is (.0005, .0010), with distribution 2 preferred below and distribution 3 preferred above.

Using this information as a guide, the series of questions at the top of figure 1 was specified. The decision maker is always asked to make the first comparison, but which of the second two he makes will depend on the choice he makes in the first. For example, if distribution 2 is preferred to distribution 1 in the first comparison, this implies that the decision maker's level of absolute risk aversion is less than .0005. He is then directed to compare distributions 1 and 3. If he prefers distribution 1, his level of absolute risk aversion is shown to be greater than −.0001. This combined with the information from the first comparison indicates that his level of absolute risk aversion lies on the interval (−.0001, .0005). Had he preferred distribution 3, his level of absolute risk aversion would have been shown to be less than .0001, which, when combined with the information from the first question indicates that it lies on the interval (−∞, .0001). Note that, given preference for distribution 1 in the first comparison, the third comparison would not provide any new information. It could serve as a consistency check, however, since preference for distribution 3 in this case would not be consistent with preference for distribution 1 in the first question.

By making interval measurements in the neighborhood of several outcome levels and interpolating between known values, lower- and upper-bound absolute risk-aversion functions can be constructed for a much wider range of outcomes. Each of the two absolute risk-aversion intervals shown in figure 2 was based on four such measurements. In this instance, net income was the performance variable, and possible values ranged from a loss of \$5,000 to a gain of \$30,000. It should be noted that the form of absolute risk-aversion functions based on interval measurements is not restricted. For decision maker A, the bounded interval slopes downward as income increases, while for decision maker B, it slopes upward and then downward. The interval measurements for both decision makers con-

[3] Meyer (1977b) shows that distribution $F(y)$ is preferred to $G(y)$ by all decision makers more risk-averse than $k(y)$ if

$$\int_{-\infty}^{y} [G(x) - F(x)]k'(x)dx \geq 0$$

for all y, and if the inequality is strict for some value of y, and that $G(y)$ is preferred to $F(y)$ by all decision makers less risk-averse than $k(y)$ if

$$\int_{y}^{\infty} [G(x) - F(x)k'(x)dx \leq 0$$

for all y, and if the inequality is strict for some value of y. In this instance $k(y)$ takes the negative exponential form, $-e^{-\lambda y}$, where λ is a constant level of absolute risk aversion. Let $F(y)$ and $G(y)$ be the cumulative distribution functions of distributions 1 and 2, respectively. Since

$$\int_{-\infty}^{y} [G(x) - F(x)][.0005e^{-.0005x}]dx \geq 0$$

for all y, and

$$\int_{y}^{\infty} [G(x) - F(x)][.0001e^{-.0001x}]dx \leq 0$$

for all y, with the inequality being strict for some y in each case, it can be concluded that distribution 1 is preferred by all decision makers more risk-averse than .0005 and that distribution 2 is preferred by those less risk-averse than .0001.

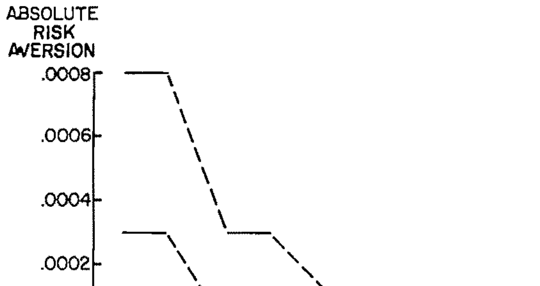

Figure 2. Interval measurements of absolute risk aversion for two decision makers

tain negative as well as positive values at some income levels. When absolute risk-aversion functions are derived from empirically estimated utility functions, on the other hand, their properties are severely limited by the functional form used to estimate the utility function (Lin and Chang). It should also be noted that the interval approach to the measurement of preferences avoids another common problem encountered in the estimation of single-valued utility functions. Because all questions posed require a choice between two uncertain prospects, biases due to preference for or aversion to gambling per se (Officer and Halter) are avoided. The greatest strength of the procedure, however, is its flexibility, which allows direct specification of the degree of precision with which preferences are measured.

Implementation of the Procedure

The discussion in the preceding section presents a method for constructing interval preference measurements, but it does not explain the mechanics of implementing this procedure. The implementation of the interval approach to preference measurement is outlined briefly in this section. A more detailed explanation is given in King and Robison (1981) along with listings of computer programs used in constructing preference measurement questionnaires and in ordering choices with the criterion of stochastic dominance with respect to a function.

Implementation of the interval approach begins with the specification of a measurement scale—a set of reference levels in absolute risk-aversion space which serve as the basis for preference measurements. Because this scale determines the degree of precision with which preference measurements can be made, careful attention should be given to its specification.

The number of reference levels on the measurement scale depends on the number of comparisons the decision maker will be asked to make as absolute risk aversion is measured in the neighborhood of any particular outcome level. As the number of choices increases, more accurate measurements can be made, but more reference levels are required. In general, if N comparisons are to be made, the measurement scale should be comprised of at least 2^N reference levels. In the example presented in the preceding section, for example, the decision maker was required to make two comparisons and the measurement scale was comprised of four absolute risk-aversion levels: $-.0001$, .0001, .0005, and .0010.

Reference levels need not be placed at regular intervals. In many instances it is desirable to concentrate them in that region of absolute risk-aversion space where the decision maker's actual level is expected to fall or in a region where relatively small changes in absolute risk aversion have a great impact on preference orderings. Experience to date indicates that most of the levels on the measurement scale should be concentrated in the risk-aversion interval between $-.0001$ and .0010. Actual measurements for a number of individuals have tended to fall most frequently within this interval, and tests on several empirical decision problems have indicated that choices are most strongly affected by changes in absolute risk aversion within this range.

Next, sample distributions must be generated, and boundary intervals on the measurement scale must be identified for as many pairs of distributions as possible. Sample distribu-

tions are constructed in a random manner by generating several hundred variates from a user-specified distribution and grouping them into sets containing an equal number of observations. Each set of observations is considered to be a distribution of outcomes, and each element of a distribution is said to have an equal probability of occurrence. The sample distributions should be defined over a relatively narrow range of outcome levels, because the decision maker's level of absolute risk aversion is said to be constant over that range. Experience to date indicates that a range of 5% to 10% of the possible range of outcomes is adequate. In past applications, six elements have been included in each distribution. More complex distributions would make decision makers' choices unduly difficult, while distributions with fewer elements may not be rich enough to make the choices interesting. The use of six element distributions also facilitates explanation of the choice situation to the decision maker, because the probability of any one element occurring can be equated directly to the probability of obtaining a specified number of dots on a single roll of a die. Distributions with either a larger or smaller number of elements can, however, be employed.

Given the measurement scale, the program that generates the sample distributions uses the criteria developed by Meyer (1977b) for stochastic dominance given lower or upper bounds on absolute risk aversion to identify the narrowest boundary interval for each pair of distributions. Absolute risk-aversion intervals defined by adjacent reference levels on the measurement scale are tested iteratively for each pair of distributions to identify the highest reference level, λ_1, such that all decision makers less risk-averse than λ_1 prefer one distribution and the lowest reference level, λ_2, such that all decision makers more risk-averse than λ_2 prefer the other distribution. These two reference levels define the boundary interval (λ_1, λ_2) for that pair of distributions.

If enough sample distributions are considered, at least one pair of distributions having a boundary interval between any two adjacent levels on the measurement scale should be identified. Once this has been done, a series of comparisons can be formulated, with each focusing on a different boundary interval. The comparisons are arranged so that the decision maker is directed through a hierarchy of choices designed to increase continually the precision of the interval measurement. In general, each comparison should focus on an interval in the center of the region of absolute risk-aversion space consistent with the decision maker's prior choices.

Series of choices among distributions centered around several outcome levels are required for the construction of an overall interval measurement. Experience to date has shown that direct measurements in the neighborhood of three or four outcome levels provide an adequate basis for the construction of lower and upper bound absolute risk-aversion functions over even a broad range of outcomes. If, for example, annual income is the performance measure for which preference information is to be elicited and the relevant income range is from 0 to \$20,000, direct measurements of absolute risk aversion could be made in the neighborhood of \$3,000, \$10,000, and \$17,000. Portions of the lower and upper bound functions based on direct measurements are connected by linear segments to determine absolute risk-aversion levels at intermediate outcome levels.

The elicitation of preferences under the interval approach is straightforward. Completion of a questionnaire comprised of four series of three comparisons takes approximately twenty minutes and requires little supervision. Experience to date has shown that decision makers find this procedure more interesting and more informative than the interview process required to elicit a single-valued utility function.

Finally, interval preference measurements are used in combination with the evaluative criterion of stochastic dominance with respect to a function to order choices. Lower and upper bound absolute risk-aversion levels for each of the outcome levels where direct measurements have been made and the outcome distributions to be ordered serve as inputs to the computer program designed to accomplish this task. A listing of that program is given in King and Robison (1981) along with a discussion of its structure and use.

An Empirical Test

A simple experiment was designed and conducted to test the effectiveness of the interval approach to the measurement of decision maker preferences. Three questionnaires were administered to a group of graduate students from the Department of Agricultural Economics at Michigan State University. The first

questionnaire employed the procedure described in the preceding sections to obtain an interval measurement of each subject's absolute risk-aversion function. The second questionnaire was used to elicit information required for the construction of a single-valued utility function for each subject. Finally, in the third questionnaire the respondents were asked to make a series of six choices between pairs of distributions, defined on the overall interval for which preferences had been measured. Information from each of the first two questionnaires was used to predict the choices made in the third questionnaire, and these predictions were compared to the actual responses. In this way the accuracy of each of the two approaches to preference measurement was tested. The distributions on the third questionnaire also were ordered by first- and second-degree stochastic dominance, so the performance of these criteria could also be evaluated.

In evaluating each approach, two criteria were considered: the number of correct predictions and the number of choices for which a definite ordering was made. A prediction was said to be correct if the respondent's choice was not excluded from the efficient set of choices and incorrect if it was excluded. The preference measure having the highest proportion of correct predictions was said to be the most accurate according to this criterion. Concern with the proportion of correct predictions is analogous to concern with the probability of Type I error in a statistical test—i.e., with the probability that a true statement will be judged false and rejected. This measure of accuracy, however, is not a good indicator of the discriminatory power of a preference measurement. First-degree stochastic dominance, which holds for all decision makers who prefer more of the performance measure to less, should never exclude a preferred choice from the efficient set and so should be perfectly accurate according to this criterion. Often, however, it also fails to exclude many choices from the efficient set. A single-valued utility function, on the other hand, is the basis for a complete ordering of choices—i.e., it always leads to an efficient set having a single element. Therefore, the number of choices actually ordered was also considered. Concern wth the discriminatory power of a criterion is analogous to concern with the probability of Type II error in a statistical test—i.e., with the probability that a false statement will be judged to be true and not rejected.

Clearly there are trade-offs between the accuracy and discriminatory power of a preference measurement. Unlike other measurement techniques and evaluative criteria, the combined use of interval preference measurements and stochastic dominance with respect to a function permits explicit consideration of these trade-offs. As the precision of the interval measurement increases, it becomes a more discriminating basis for the ordering of choices, but the probability of excluding preferred choices from the efficient set also increases. Such trade-offs between accuracy and discriminatory power were analyzed in the experimental test of the interval approach to the measurement of preferences. Direct interval measurements were made at three levels of income—the relevant performance measure in this instance. These measurements were based on a sequence of four questions at each income level. By constructing interval measurements on the basis of information available at the end of each question, however, four preference measurements—each more precise than the one which preceded it—were made for each subject.

Nine of ten subjects correctly completed all three questionaires.[4] Because each subject made six choices on the third questionnaire, each preference measurement was used to predict a total of fifty-four choices. The results of the experiment are presented in table 2. They show a clear trade-off between accuracy and discriminatory power. First-degree stochastic dominance and the single-valued utility function are at opposite extremes in this trade-off relationship, and the interval measurements are arrayed between the two. Several factors should be noted. With regard to the accuracy of the interval measurements, it falls at a relatively constant rate as the number of questions posed increases, but even at the higher levels of precision it exceeds that of the single-valued utility function. The discriminatory power of the interval measurements, on the other hand, increases dramatically as the number of questions asked at each income level increases. In contrast, first- and second-degree stochastic dominance clearly do not

[4] The tenth subject made comparisons out of order on the interval measurement questionnaire and made several inconsistent choices. The suggested format of the questionnaire has since been revised to reduce the possibility that comparisons will be made out of order. The problem of inconsistent choices, which has also occurred in other trials of the procedure, suggests that it may be desirable to incorporate consistency checks into the questionnaire. To date the value of such checks has not been formally evaluated.

Table 2. Performance Indicators for Alternative Preference Measures

Performance Indicator	Interval Measurement: Number of Questions 1	2	3	4	Single-Valued Utility Function	First-Degree Stochastic Dominance	Second-Degree Stochastic Dominance
1. Percentage of choices predicted correctly	98	88	78	72	65	100	98
2. Percentage of choices ordered	9	50	83	91	100	0	7

discriminate well among the distributions the subjects in the experiment were asked to order.

Concluding Remarks

These experimental results demonstrate how interval preference measurements allow explicit consideration of trade-offs between accuracy and discriminatory power of preference measurements. Unlike single-valued utility functions, they are not exact representations of preferences and so are not as likely to eliminate a preferred choice from consideration. Unlike the representations of preferences assumed under commonly used efficiency criteria, they are empirically based and can be made as precise as desired.

This experimental test was conducted under controlled conditions quite different from an actual decision-making environment. The interval approach to preference measurement also has been used in a more practical setting—a series of extension workshops—as a tool to help farmers think more clearly about their risk preferences. The interval measurements in figure 2 were made at such a workshop. The seventeen farmers for whom absolute risk-aversion intervals were constructed found the choices in the interval measurement questionnaire to be interesting and had little difficulty completing it without supervision. Their preferences ranged from the extremely risk-averse to the extremely risk-loving. Several discernible patterns did emerge, however. Most individuals exhibited increasing absolute risk aversion over lower income levels and decreasing absolute risk aversion at higher income levels. For most, the interval measurement of absolute risk aversion included negative as well as positive values at some income levels. In fact, only four had lower-level absolute risk-aversion functions that were everywhere non-negative. This casts serious doubts on the reliability of single-valued utility functions, which typically restrict the form of the absolute risk-aversion function, and on the applicability of a criterion such as second-degree stochastic dominance, which holds only for decision makers who are risk-averse at all income levels.

Finally, in an application of stochastic dominance with respect to a function concerned with farm enterprise choices under price, yield, and weather uncertainty (King, and Robison, 1981), interval measurements made in the extension workshops were used to order 500 randomly selected farm plans. For the two decision makers whose interval measurements are given in figure 2, each efficient set contained less than ten plans, and only one plan appeared in both sets. This demonstrates that interval measurements can be used to represent differences in preferences and that they can be used effectively to eliminate a large number of choices from consideration in a realistic decision situation.

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The Potential Role of Multilevel Programming in Agricultural Economics

Wilfred Candler, Jose Fortuny-Amat, and Bruce McCarl

This paper discusses a new class of problem related to mathematical programming but with two separate decision makers in hierarchical relationship, each with his own objective function and control over distinct but interacting variables. The relationship of this problem to agricultural (energy and environmental) policy problems is developed, together with the relationship of this new problem structure to mathematical programming, game theory, control theory, and principal agent theory. Suggested computational approaches are reviewed, along with the solution to two illustrative examples of the use of the technique.

Key words: agricultural policy, mathematical programming, multilevel programming.

In this paper we wish to take the reader beyond sector modeling to the next logical step, the use of sector models to find optimum agricultural policies. As will be illustrated, this leads to a new model structure, which has been called multilevel programming.

A key characteristic of agricultural (or economic) policy problems is that the government, or other policy makers, have only a limited range of variables under their direct control. Other variables, acreage of crop grown, tons of fertilizers applied, choice of crop, machinery investment, and the like, are decided by a myriad of decentralized decision makers following a variety of behavioral rules. While models have been constructed to reflect the competitive behavior of decentralized decision makers in the agricultural sector, little attention has been given to a clear articulation of policy objectives or the acceptable range for policy variables such as taxes, subsidies, quantitative limitations, or entitlements.

Consider for a moment an agricultural sector model of the CHAC type (Duloy and Norton), in which downward-sloping demand functions and upward-sloping input supply functions are used to calculate equilibrium prices and quantities. Such a model has been used to represent competitive behavior by the agricultural sector. Given such a model, in which the objective function of maximizing the area between the demand and supply functions serves to locate the competitive solution, policy experiments can then be performed to examine the results of price policies, taxes, subsidies, production quotas, supply shortages, and the like. For any one experiment, i.e., for any one setting of the policy variables, the model will yield the corresponding competitive solution. Any number of experiments, limited only by time and the research budget, can be performed. So far so good, but note that this experimental approach finessess the need to state explicitly "the policy problem." Typically, it fails to define clearly (*a*) the full spectrum of variables under the control of the policy maker, (*b*) the acceptable ranges for these variables, or (*c*) the policy objective function.

Authors can be found who will assert that it is better not to be tied to a single objective function, that it is better to present a range of scenarios and let the policy maker choose. Such authors are content to present "good" policy options, without any idea how far short these options fall from the best policy. If we accept the challenge of attempting to find the best policy in the context of a sector model, then it is evident that we have two types of variables (those under the direct control of the policy maker and those not under his direct control) and two objective functions (the pol-

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icy maker's objective function and the objective function that determines the selection of variables not under the direct control of the policy maker). This immediately distinguishes the policy problem from mathematical programming—and from the multilevel (decomposition) algorithms of the type discussed by Dirickx and Jennergren, which are concerned to find efficient solutions to mathematical programming problems with one objective function and one set of control variables—which recognizes only one objective function and only one class of variables (all under the control of a single decision maker). Equally, game theory is of little help because most variables are continuous; and even if we were content with a discrete approximation, this would involve enumeration of the entire policy space and all possible responses to each policy setting. So long would be spent enumerating that we would never have time to choose.

While this paper focuses particularly on the derivation of optimum economic policy, the same model structure can be applied to other policy problems (environment, energy, etc.) or, indeed, to private decision problems with the appropriate hierarchical structure.

In the next section the multilevel programming problem is defined, for the "usual" linear two-level case. The third section relates multilevel to multiobjective programming, and the fourth section shows that multilevel problems can have local optima. A fifth section relates multilevel programming to related problem structures, the sixth section briefly reviews solution principles, and the seventh section presents illustrative numerical results. A final section summarizes the ideas which have been advanced. No automatic, fast, large-scale solution procedures are available, largely because the field is too new for the various suggestions to have been tested and implemented in large codes.

Problem Definition

First consider a standard linear programming problem: P1: Find x_1, such that

$$z_1 = \max_{x_1} c_1 x_1, \tag{1.1}$$

subject to

$$A_{11} x_1 \leq b_1, \tag{1.2}$$

$$x_1 \geq 0, \tag{1.3}$$

where this problem might involve any of the following applications: (*a*) an agricultural sector model (Duloy and Norton) such as CHAC, where the objective function (1.1) serves to locate the competitive equilibrium solution; (*b*) a river basin model (Duloy et al., Kutcher), where (1.1) again serves to find the competitive equilibrium solution; (*c*) and the like.

Now, suppose that a policy maker (*a*) knows the structure and coefficients of P1, and (*b*) can influence through the setting of policy variables some of the parameters within c_1 and b_1 (and even A_{11}, through activities such as research and development and extension), but (*c*) cannot control (any element of) x_1 directly, and (*d*) that the levels of x_1 enter into the utility function $U_2(x_1)$ of the policy maker.

Influencing the size of c_1 typically would be achieved by tax or subsidy policy or possibly by fixing mandatory buying and selling prices. In the case of an input-supplier, c_1 would be influenced directly by the prices he chooses to charge. Influencing the size of b_1 might involve production quotas, set-aside acres or control over quantitative supplies of inputs. Because changes in c_1 and b_1 may have direct costs or benefits to the policy maker, his utility function should perhaps be better expressed as $U_2(x_1, c_1, b_1)$. Note that in these examples we are dealing with strictly hierarchical decision structure. Once the policy maker has decided on the values of c_1 and b_1, the lower level (or behavioral) decision maker simply solves P1, in the light of these values. There is no element of bargaining.

As mentioned earlier, the usual way in which hierarchical decision problems of this sort are studied is to build an explicit model of P1, and then solve it for a range of values of c_1 and b_1, leaving it to the outer decision maker to evaluate his utility function for the resulting x_1, and c_1, b_1.

The traditional approach is basically sloppy since no account is taken of the feasible range for c_1 and b_1, nor is it possible to select the experimental values of c_1 and b_1 in regions of likely interest to policy makers. And finally, it makes very little sense, having gone to the expense of constructing and calibrating P1, to fail to find the optimum available policy. In the next section we touch briefly on the derivation of the policy objective function. In the balance of this section, we simply assume that a satisfactory estimate of the policy maker's objective function U_2 is available and is convex.

Given this assumption, we can state the two-level programming problem as P2: find x_1, x_2, and d_2, such that

$$(2.1)\quad z_2 = \max_{x_2, d_2} c_{21}x_1 + c_{22}x_2 + c_{2d}d_2 + d_2Q_2x_1,$$

subject to

$$(2.2)\quad G_2d_2 + A_{21}x_1 + A_{22}x_2 \leq b_2,$$

$$(2.3)\quad x_2, d_2 \geq 0,$$

where x_1 solves

$$(2.4)\quad z_1 = \max_{x_1 | x_2, d_2} (c_1{}^0 + d_2)x_1,$$

subject to

$$(2.5)\quad A_{11}x_1 \leq b_1{}^0 - A_{12}x_2,$$

$$(2.6)\quad x_1 \geq 0,$$

where x_2 gives the set of allocation policies available to the policy maker, and d_2 gives the set of pricing policies available to the policy maker.

For given $x_2 = \bar{x}_2$, $d_2 = \bar{d}_2$, then (2.4) to (2.6) corresponds to the linear programming problem P1, with

$$c_1 = c_1{}^0 + \bar{d}_2,\ b_1 = b_1{}^0 - A_{12}\bar{x}_2,$$

i.e., it is the inner decision maker's problem, after the policy maker has selected the policies (x_2, d_2) and thereby b_1, c_1.

Restraints (2.2) to (2.3) restrict the acceptable values of the outer (policy) variables d_2, x_2, in the light of the values of x_1.

The outer objective function (2.1) contains linear terms for x_1, x_2, and d_2, and a quadratic term in d_2x_1, because this is the total subsidy or revenue from per unit subsidies and taxes, d_2, multiplied by quantity produced or used, x_1.[1]

In general, the inner problem, P1, could be replaced by any mathematical programming problem; and (2.2) to (2.3) could be replaced by nonlinear constraints, while (2.1) could be of higher order than quadratic.

The important features of the two-level programming problem P2 are (*a*) the hierarchical nature of policy decision making is explicitly recognized, where (*b*) the variables under the control of the policy maker, d_2, x_2, are clearly distinguished from the variables, x_1, which are under the control of the inner (or behavioral) decision maker; and (*c*) the existence of two, potentially conflicting, objective functions is explicitly recognized.

Whether or not an acceptable algorithm for P2 is available, the use of the two-level structure to express a policy problem is a great aid to intellectual rigor. The model structure forces on the policy analyst questions, such as: Which variables are under the control of the policy maker? What are the constraints to acceptable values of these variables? What are the policy objectives? In particular, this formulation should help avoid the misuse of sector models, whereby a simple technical objective is used in place of a behaviorally consistent obejctive. As McCarl and Spreen have said, "A classic example of misuse is one where a research team convinces itself that the country wishes to optimize nutritional production and then the research team replaces (or originally formulates) the objective function to do so. One needs only to wonder how many farmers will forego income to produce calories for the aggregate population to see the fault of this modelling strategy" (p. 98).

Multiobjective and Goal Programming

The typical policy problem is characterized by (*a*) more than one objective or goal that the policy maker wishes to maximize or observe and (*b*) incomplete control over all variables. Multiobjective and goal programming emphasize the former feature, while multilevel programming emphasizes the latter.

A recent review of multiple objective and goal programming makes the distinction between situations in which all variables are, or are not, under the direct control of one decision maker (or committee): "The Goal Programming approach can be an extremely useful tool for situations in which the decision maker . . . commands the system in question (i.e., many private sector decisions) . . ." (Willis and Perlack, p. 71). This is distinguished from policy situations in which no one individual controls all variables. Unfortunately, the literature in this area has failed to recognize that in the usual case, where not all variables are under the control of one decision maker, it can be badly misleading to analyze alternatives as if all variables were under the control of a single decision maker. For most policy (i.e., public sector) problems, this in-

[1] The interaction of d_2 and x_1 may belong in the constraints. However, the problem as stated is analytically simpler and corresponds to Lagrangian relaxation (Geoffrion) of a problem with the quadratic term in the constraints.

validates one-level approaches. Kornai and Liptak recognized that some variables may not be under the direct control of policy makers, but even their contribution assumes harmony in the central and decentralized objective functions.

Equally, the presentation given so far in which a single, known, objective function is assumed to exist for the policy maker might be attacked as too simplistic. Fortunately, the multiobjective and goal-programming literature has considered the problem of how an unknown (or only subjectively known) objective function in several dimensions may be reduced to, or approximated by, a locally linear objective function (Candler and Boehlje, Keeney and Raiffa, Zeleny).

This paper does not pursue the question of derivation of the policy objective in greater depth, because the problem is complex enough even if this objective is known a priori. Let us comment, however, that use of multilevel programming to identify optimum or good policy responses to an arbitrary approximation to the policy objective, in order to improve heuristically the approximation, is completely consistent with the approach being described. If the objective is known, then we can proceed to an optimum or good solution. If the objective is not known a priori, then a detour may be necessary to learn more about the policy objective function before proceeding to results which are more than an aid to heuristic improvement of the statement of the objective function.

Mathematical Difficulty

The multilevel programming problem, unfortunately, is analytically difficult. Multilevel programming problems (which encompass linear programming as a subset) may have many local optima, even though all functions are linear. It is a simple matter to demonstrate this difficulty. As will be shown later, no completely satisfactory algorithm is available for solution of such problems. To see the nature of the nonconvexities which may arise in policy problems, consider the following: P2E, find x_{11}, x_{12}, and x_{21}, such that

$$z_2 = \max_{x_{21}} 2x_{11} + 4x_{12},$$

where $0 \leq x_{21} \leq 1$, subject to

$$\left.\begin{aligned} z_1 = \max_{x_{11},x_{12}|x_{21}} & - x_{11} - x_{12} \\ -x_{11} - x_{21} &\leq -.5 \\ -x_{12} + x_{21} &\leq .5 \\ x_{11}, x_{12} &\geq 0 \end{aligned}\right\},$$

which is the inner problem.

For a given value of x_{21}, the inner problem has solution

$$\left.\begin{aligned} x_{11} &= .5 - x_{21} \\ x_{12} &= 0 \end{aligned}\right\}$$

if $0 \leq x_{21} \leq .5$, or

$$\left.\begin{aligned} x_{11} &= 0 \\ x_{12} &= x_{21} - .5 \end{aligned}\right\}$$

if $.5 \leq x_{21} \leq 1$.

These solution values, together with the resulting objective function value for the outer problem are illustrated in figure 1. Despite the inner problem being a well-behaved linear program for any given value of x_{21}, and despite the outer objective function being linear, there are two local optima, viz., $z_2 = 1$ for $x_{21} = 0$ and $z_2 = 2$ for $x_{21} = 1$.

Quite apart from mathematical difficulties introduced by this feature of multilevel pro-

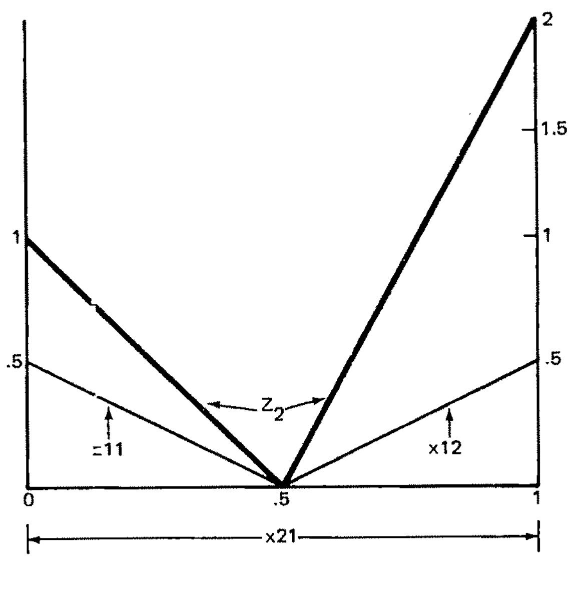

Figure 1. Graphical solution of sample problem

gramming, it also tells us that a mix of good policies may be bad policy. Clearly, a 50:50 mix of the policy of setting $x_{21} = 0$ and $x_{21} = 1$ results in $x_{21} = .5$, with a much lower value of the objective function than characterized either of the policies contributing to the mix.

The existence of more than one local optimum means that the problem cannot be transformed and solved as a linear programming problem. Rather, some form of implicit research of all local optima is called for. As we shall see, various authors have appealed to integer programming, branch and bound, specially ordered sets, and restricted basis entry to achieve their implicit search.

In the special case where the outer decision maker wishes to permit the inner decision makers to maximize their objective function, it may be possible to solve the problem by linear programming (Bisschop et al.). Indeed, in the special case where the inner and outer objective functions are the same and there are no outer constraints, the problem is simply a linear program.

Related Problem Structures

We have now seen that even where all functions are linear, we cannot in general solve even a two-level problem by linear programming. Before passing on to a brief review of computational approaches and empirical examples, it may help put the multilevel problem in perspective if we consider some related problem structures, namely parametric programming, game theory, control theory, and principal agent theory.

Parametric Programming

Looking again at the two-level problem P2 and assuming Q_2 is null so that there are no quadratic terms, it is tempting to guess that the solution to P2 must be among the solutions to the parametric programming problem: P3, for $\phi = 0$ to 1, find x_1, x_2, and d_2, such that

$$(3.1)\quad z_3 = (1 - \phi)(c_{21}x_1 + c_{22}x_2 + c_{2d}d_2) + \phi(c_1^0 + d_2)x_1 \text{ a max,}$$

subject to

$$(2.5)\qquad A_{11}x_1 + A_{22}x_2 \leq b_1^0,$$

$$(2.2)\qquad G_2d_2 + A_{21}x_1 + A_{22}x_2 \leq b_2,$$

$$(2.3, 2.6)\qquad x_1, x_2, d_2 \geq 0.$$

This describes an outer envelope of feasible values of z_1 and z_2, but the solution to P2 may not belong to this envelope. The reason for this is that, for fixed $x_2 = \bar{x}_2$ and $d_2 = \bar{d}_2$, the inner decision maker has the possibility of selecting the x_1 to maximize this objective function (2.4) and without regard to the outer constraints (2.2).

In one example (Candler and Townsley), where (2.1) was maximized over x_2 and x_1 subject to the constraints on P3, the solution value for z_2 was 50,235. When x_2 was fixed at this value and the inner problem resolved, the value of z_2 fell to 15,435, which illustrates the wide degree of discretion that may remain for the inner decision maker even after the values of the policy variables have been fixed.

Game Theory

A bimatrix game may be formulated equivalent to problem P2, with the players being the government and the private sector. The first step in constructing such a game would be to form the payoff matrix, which requires the determination of the strategies available to both players. Let X_2 be the set of admissible strategies for the government. The elements of this set are determined by economic and noneconomic considerations. Assume the government considers only certain discrete levels of policy measures. For example, the government may decide on a tax level among only predetermined figures, say 7%, 8%, or 9%, but it will disregard any other values. Let the set S contain all vectors $(\mathbf{x}_2,\mathbf{d}_2)$ of policy measures that the government considers as practical and feasible candidates to be implemented. The set S evidently is finite. Combining economic and noneconomic reasons results in the following definition for the finite set X_2:

$$X_2 = [(\mathbf{x}_2,\mathbf{d}_2) \geq 0\colon (\mathbf{x}_2,\mathbf{d}_2)\epsilon S,\ A_{11}x_1 + A_{12}x_2 \leq b_1, \text{ and } G_2d_2 + A_{21}x_1 + A_{22}x_2 \leq b_2 \text{ for some } x_1 \geq 0].$$

Let X_1 be the set of admissible strategies for the decentralized decision makers (industry); for any $(\bar{\mathbf{x}}_2,\bar{\mathbf{d}}_2)\epsilon X_2$, this set could be found by enumeration of all extreme points of the subproblem's convex region:

$$A_{11}x_1 \leq b_1 - A_{12}\bar{x}_2$$

$$x_1 \geq 0.$$

Therefore, X_1 is the set of all extreme points of the convex polyhedrons defined by the above set of constraints for all possible values $(\mathbf{x}_2,\mathbf{d}_2)\epsilon X_2$:

$$X_1 = [x_1 \geq 0,\ x_1 \text{ is an extreme point of } A_{11}x_1 \leq b_1 - A_{12}\bar{x}_2 \text{ for some } (\bar{\mathbf{x}}_2,\bar{\mathbf{d}}_2)\epsilon X_2].$$

After defining the sets of strategies for both players, the next step in constructing the bimatrix game is the determination of the payoffs. Evidently, for any triple $(\bar{d}_2,\bar{x}_2,\bar{x}_1)$ such that $(\bar{\mathbf{d}}_2,\bar{\mathbf{x}}_2)\epsilon X_2$ and $\bar{x}_1\epsilon X_1$, the payoff to the government is $c_{21}\bar{x}_1 + c_{22}\bar{x}_2 + c_{2d}\bar{d}_2 + \bar{d}_2 C_2\bar{x}_1$ and the payoff to industry is $(c_1{}^0 + \bar{d}_2)\bar{x}_1$, as given by the respective objective functions. To completely specify the payoff matrix, we will assign the payoff pair $(-\infty,-\infty)$ if for strategy $(\mathbf{x}_2,\mathbf{d}_2)\epsilon X_2$ there is no feasible $x_1\epsilon X_1$.

In order to find a proper solution concept for the game just constructed, some behavioral remarks about its nature should be made. Because the decision-making process is performed sequentially in two stages, with the government announcing its strategy in the first stage, we have a situation where the government acts as the leader and the industry acts as the follower (decides on its plan of action after the government's strategy has been announced). Under these circumstances it has been shown (Simaan and Cruz) that the best strategy to use by the player acting as leader is the Stackelberg strategy.

There are two difficulties with this approach. In the first place, the policy variables d_2,x_2 generally will be continuous variables, whereas the set X_2 would refer to a finite number of discrete values of d_2, x_2. This is not a substantive objection since, in principle, the grid X_2 can be made arbitrarily fine. The substantive objection is that this approach involves an explicit (not implicit) search over the policy grid X_2. For each member of X_2, linear programming problem P1 would need to be solved to find $x_1 = f(\mathbf{x}_2,\mathbf{d}_2)$, and hence $z_2 = g(\mathbf{x}_2,\mathbf{d}_2)$. For any reasonable grid X_2 and nontrivial problem P1, this would be computationally exhorbitant.

Control Theory

Control theory, as reviewed recently by Rausser, presents a somewhat similar problem structure, the major differences being that control theory is concerned with the evolution of a system over several periods in which stochastic elements may be important, learning can take place, and the form of the function determining system evolution is known. By contrast in multilevel programming, we are concerned with a two-stage process operating under certainty, so that stochastic elements and learning cannot occur, and where evaluation of the functional form which determines the evolution of the system is the nub of the problem. Control theory deals with a dynamic system while multilevel programming deals with a static equilibrium. Nevertheless, multilevel programming can be viewed as a special case of control theory.

Principal Agent Theory

A third area of economic inquiry which is related to the problem as formulated above is the area of principal agent theory. This was recently reviewed by Holstrom and deals with the problem of maximizing an abstract functional form subject to a maximum of some problem's objective function. The principal is analogous to the government in our situation and private industry is analogous to the agent. This has been an area of considerable theoretical inquiry; however, it has not, at this point, yielded a rich empirical literature. The distinguishing feature of principal agent theory is that the principal can decide on a level of enforcement effort to influence the behavior of the agent, cf., enforcement effort which might be associated with an effort to fix gasoline prices below their equilibrium value. So again, multilevel programming is a simplification of the general principal agent theory, where enforcement effort is zero.

The formal statement of the principal agent problem can be written (Holstrom, p. 76): P4 find x_1,x_2, such that

(4.1) $\quad \max E\{G[x_2 - s(x_2)]\}$,

subject to

(4.2) $\quad E\{H[s(x_2),x_1]\} \geq \bar{H}$,

(4.3) $\quad x_1\epsilon \operatorname{argmax} E\{H[s(x_2),x'_1]\}$,

(4.4) $\quad x'_1\epsilon X_1$,

where the notation "argmax" denotes the set of arguments that maximize the objective function that follows. In this case, X_2 is the enforcement effort and x_1 the variables not under the direct control of the principal.

Summary

None of the above should be construed to argue that multilevel programming is a more appropriate tool than the other techniques mentioned. Rather, the discussion illustrates the theoretical relationship of multilevel programming to other lines of inquiry. Since multilevel programming is the newcomer in the theories being discussed, we have tried to emphasize that it is genuinely different and to avoid the possibility that it will be dismissed as a special case of already well-understood quantitative techniques.

As illustrated by the recent review by McCarl and Spreen, agricultural economists have been active in the construction of sector models, almost always motivated by an interest in economic development and agricultural policy. An obvious question is: Given a sector model, how can policy recommendations be optimized? It was exactly this question which led to the formulation of multilevel programming by Candler and Norton. It should therefore come as no surprise, that of the alternative analytical techniques, multilevel programming should be the most appropriate for this particular application.

Solution Principles

At this writing, only limited numerical experience exists for the solution of multilevel programming problems. No attempt is made here to provide a comprehensive review of the suggested algorithms; rather, we are concerned to identify the approaches which have been explored and point the interested reader to the relevant papers.

A first "classical" approach, by Fortuny-Amat and McCarl, replaces the inner problem (2.4) to (2.6) by its Kuhn-Tucker conditions, which are then included as explicit constraints in addition to (2.1) and (2.3). As well as the addition of linear constraints, this adds the Kuhn-Tucker complementary slackness conditions. Fortuny-Amat and McCarl replace the complementary slackness conditions by zero-one integer constraints, thus producing a mixed integer programming problem.

Bard and Falk carry out the same transformation but initially ignore the complementary slackness conditions, using the specially ordered sets algorithm (available on Apex 3 software). Bialas, Karwan, and Shaw have shown that a parametric raising of the policy objective, while a complimentary pivot algorithm is used to satisfy the Kuhn-Tucker conditions, can be used to find the global solution to P2.

Bialas and Karwan also have observed that if (2.2) is ignored, then the solution to P2 occurs at an extreme point of the convex hull (2.3), (2.5), and (2.6). They then propose a branch and bound search of these extreme points, starting from the point with highest value of z_2. This corresponds to enumeration of all feasible bases for the inner problem, such that z_2 exceeds the solution value for P2.

Another "classical" approach is due to Bracken and McGill (1973, 1974). It simply recognizes the nonlinear nature of the problem and applies a generalized nonlinear search algorithm: SUMT.

Candler and Townsley assume that $d = 0$, and a myopic search for a better basis is pursued until a local optimum appears to have been reached. At this stage, reduced-cost information is examined to establish a set of vectors, at least one of which must be included in any better basis.

Another special case, where the objective function of the outer problem is in total opposition with that of the inner problem (i.e., a zero-sum situation), has been considered by Falk.

To date, computational experience with all of the proposed approaches has been unpromising. Either the algorithm requires a special purpose code not available in large packages or problem size increases substantially as it is transformed to be solvable by existing large-scale codes.

The largest problem solved to date was for an agricultural region in Mexico. This involved 50 constraints, 300 behavioral variables, and 20 policy variables. A heuristic search procedure was employed, which found a solution value of 49,950 after establishing an upper bound of 50,235. The heuristic procedure is reported by Candler and Townsley. For large-scale problems, this heuristic may still be the most practical approach.

Illustrative Examples

Applications to date have been more illustrative than anything else. Nevertheless, applications have been made in the context of the allocation of irrigation water into a canal

command and optimal pricing policy for a spatial monopolist.

Irrigation Policy

In this case, we considered a model of an irrigation canal command, where policy administrators could control the cotton quota and water releases. Two alternatives were considered for water release, the first where the government controlled only the annual availability of water to the canal command (leaving its distribution by the month to be decided by the farmers, possibly via a cooperative), and the second where the monthly availability of water was controlled by the government. Two policy objective functions were considered. The first involved the maximization of value added at international prices, and the second, the maximization of employment. In all cases, farmers were assumed to maximize value added at local prices (and there are marked differences between domestic and international prices, in this case).

Upper and lower bounds and "high point" solutions for the two policy objective functions are shown in table 1 for both cases, where annual and where monthly water deliveries are controlled by the government.

The upper bounds were obtained by maximizing the relevant objective over all variables (i.e., as if policy and behavioral decision makers were cooperating to maximize the relevant objective). These upper bounds are given in columns 1, 2, and 3. They illustrate that substantial substitution possibilities exist within the model. Thus, depending on choice of objective functions, the value of output at international prices can range from 110,451 down to 39,208; employment can range from 16,894 to 22,435. The extreme difference in domestic and international prices can be seen from the first and third row of table 1.

Lower bounds, columns 4 to 7, are obtained by fixing the relevant policy variables (cotton quota and total water in columns 4 and 5, and cotton quota and monthly water in columns 6 and 7) and maximizing over the behavioral variables (areas of crops) with respect to local prices. In columns 6 and 7, where monthly water allocation is controlled by the government, this change in objective function yields the same plan, i.e., upper and lower bounds coincide, and the given water allocations gives the globally optimum plan with respect to the two objective functions. It should be remarked that the two plans have markedly different implications for employment and value added at international and at domestic prices.

In columns 4 and 5, the lower bound is less than the upper bound, and in each case the value added at local prices has increased (i.e., for these given settings of the cotton quota and total water allocation, farmers have been able to change their cropping pattern so as to increase their incomes, with adverse effects on value at international prices or employment).

It may also be remarked that rounded to the nearest integer (as the results in table 1 have been), column 4 appears to dominate substantially column 5. In fact, the employment lends to five places are

Col. 4	17036.02988,
Col. 5	17036.29331,

so that column 5 does call for more employment than column 4. Given the very high cost of this last fraction of job, in terms of value added (both at local and international prices), it is highly likely that column 4 would be felt to be preferable to column 5.

The lower bounds were obtained by the simple expedient of fixing the policy variables at their upper-bound solution values.

Using a heuristic developed by Candler and Townsley, we were able to search for other, better settings of the policy variables. Only one other good setting, "high point," was found with respect to international prices (yielding 109,183 versus a lower bounds of 107,427 and upper bound of 110,451). Two high points were found with respect to labor. The first (col. 9) was better than the lower bound on employment, but worse than the high point (col. 8) found in an attempt to maximize with respect to international prices. The second high point for labor, while much less than the upper bound, was better than any other known solution where the behavioral decision makers had been free to maximize with respect to their own objective function.

At this stage, no great significance should be attached to the numbers obtained, since this was an "academic exercise" without policy makers' involvement. The important thing is that given a model and given a policy objective function, it is now possible to use the model to search for good settings of the policy variables. Using any of the exhaustive search

Table 1. Policy Alternatives

		Upper Bounds			Lower Bounds				High Points		
	Units	1 Int'l. Prices	2 Employ-ment	3 Domestic Prices	4 Int'l. Prices	5 Employ-ment	6 Int'l. Prices	7 Employ-ment	8 Int'l. Prices	9 Employ-ment	10 Employ-ment
Int'l. prices	—	110,451	39,208	109,182	107,427	55,530	110,451	40,331	109,183	55,350	97,832
Employment	man-days	16,894	22,435	17,481	17,036	17,036	16,894	22,435	17,481	17,290	17,858
Domestic prices	—	54,706	23,520	57,042	56,158	48,696	54,706	24,166	57,042	48,414	51,494
Cotton quota	area	85.44	0	85.44	85.44	0	85.44	0	85.44	0	0
Total water	(1000's cubic mc.)	1,641	2,377	1,693	1,641	2,377	1,641	2,377	1,688	2,411	1,640
Water Jan.	(1000's cubic mc.)	0	0	0			0	0			
Feb.	(1000's cubic mc.)	193	275	199			193	275			
March	(1000's cubic mc.)	194	263	199			194	263			
April	(1000's cubic mc.)	127	268	137			127	268			
May	(1000's cubic mc.)	181	101	182			181	101			
June	(1000's cubic mc.)	223	157	225			223	157			
July	(1000's cubic mc.)	275	275	275			275	275			
Aug.	(1000's cubic mc.)	154	259	158			154	259			
Sept.	(1000's cubic mc.)	24	275	33			24	275			
Oct.	(1000's cubic mc.)	44	190	54			44	190			
Nov.	(1000's cubic mc.)	62	141	67			62	141			
Dec.	(1000's cubic mc.)	165	174	164			165	171			

techniques, one can even derive optimal settings of the policy variables.

Monopolistic Pricing

A second problem (Fortuny-Amat and McCarl) considered involved a fertilizer dealer who enjoyed a geographical monopoly and could take competitors' prices as given. In these circumstances, his control variables were the prices charged for his fertilizers in different forms, always subject to the knowledge that farmers would purchase from the least-cost source. The farmers (behavioral problem) had the choice of purchasing from our fertilizer dealer or from dealers in the neighboring regions, and their decisions with respect to quantities are assumed to be made with cost minimization as the sole objective (we assume farmers need a fixed amount of fertilizer). The dealer of interest wanted to maximize profit which, in this case, involves a decision with respect to price only, since the quantities sold depend on the farmers' decision.

We solved this problem using the Fortuny-Amat and McCarl procedure to obtain the results in table 2.

Note that if the formulation ignored the existence of the sub-problem's objective function, the outer decision maker would act as a monopolist facing a fixed demand and thus could raise prices without limit.

Table 2. Global Optimum (Price per lb.)

	Purchasing	
Purchasing Modes	Dealer[a]	Competitor
At plant	.08321	.07317
Delivered	.09041	.08748
Delivered & applied	.09334	.09334
At plant w/applicator rental	.08421	.07903
Delivered w/applicator rental	.09141	.09334
	Sales (Pounds)	
Sale Mode	Dealer	Competitor
At plant	—	6,849,315.07
Delivered	—	
Delivered & applied	3,150,684.93	
At plant w/applicator rental	—	
Delivered w/applicator rental	—	
Total Sales	3,150,684.93	6,849,315.07

[a] Base price: $P_0 = 0.08321$.

Summary and Conclusions

An uncharitable summary of this paper might be that the authors can recognize multilevel programming problems, but they cannot solve them. Perhaps that is a good summary, but let us state this the other way around:

(*a*) The two-level nature of most policy problems means that they are not generally amenable to solution by mathematical programming. Furthermore, solutions obtained by dint of ignoring the behavioral, or lower level, decision function are likely to be seriously misleading.

(*b*) Multilevel programming provides a useful analytical framework for thinking about policy, because it forces a clear distinction between the variables policy makers' control and those they do not. It provides a quantitive framework for the oft-observed difference between private and public interest.

(*c*) In certain special cases, solutions may be available relatively easily using linear programming, or a suitably modified code (Bisschop et al.).

(*d*) The existing practice of running policy scenarios to scan the policy alternatives can, of course, continue to be used, pending further algorithmic developments. Hopefully, the explicit statement of the two-level problem will, in these cases, be a useful prop to intuition in selecting interesting scenarios to examine.

(*e*) In the meantime, the "unsolved" algorithmic problems of multilevel programming should provide a fertile field for Ph.D. theses, for those suitably qualified and inclined.

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Notes

The Impact of Increased Alcohol Production on Agriculture: A Simulation Study

Steven B. Webb

The higher prices of petroleum and risks of an Organization of Petroleum Exporting Countries (OPEC) embargo have stimulated the search for alternative liquid motor fuels, including alcohol from renewable sources (Alcohol Fuels Policy Review, Office of Technology Assessment, Paul). Any plant matter can be converted to alcohol, but in the near future the main input in the United States will be corn, because the technology for using the other inputs is not yet so well developed.

The federal and some state governments have enacted tax exemptions for fuel mixtures that include grain alcohol, i.e., gasohol. Because the alcohol content of gasohol is only 10%, the effective subsidy per gallon of alcohol is ten times the amount of the tax exemption. So, exemption from the 4¢ federal tax gives an effective subsidy of 40¢ per gallon of alcohol, and the effective state subsidies add on another 10¢ to a dollar (in Iowa) per gallon of alcohol (Alston, p. 10). The wholesale price of ethanol is less than a dollar above the pretax wholesale price of gasoline. The enacted subsidies are, therefore, inducing rapid increases in the production and consumption of fuel alcohol. Furthermore, a recent study predicts that after the mid-1980s, fuel alcohol will be increasingly economically attractive even without the subsidy (Schnittker Associates, p. 44).

The supply curve of grain alcohol depends chiefly upon the supply of corn and other feedstocks and upon the supply of capital and labor. In the intermediate and long-run (five years or more), one can assume an infinitely elastic supply of labor and capital to an industry as small as grain alcohol would be even under the most grandiose schemes. Federally subsidized loans for alcohol distilleries will further assure that the supply price of capital does not rise as the industry expands. The slope of the alcohol supply curve will depend chiefly on (in)elasticities of supply and demand in the agricultural sector. Agricultural inputs currently account for over half the cost of grain alcohol.

This paper seeks in one sense to estimate the upward slope of the supply curve of ethanol by estimating the response of agricultural prices to various levels of corn alcohol production. An alcohol fuel program is, on the other hand, an agricultural policy as well as an energy policy. So a second purpose of this paper is to predict the impact of increased alcohol fuel production on important dimensions of U.S. agriculture.

The first section of the paper will describe in detail the linkages between agriculture and alcohol production from corn. The next section tells some relevant features of the model used for the simulation—the U.S. Department of Agriculture's (USDA) NIRAP—and describes the results of the simulation experiments. U.S. agriculture appears well able to adapt to the impact of increased alcohol production. Consequently, the upward slope of the alcohol supply curve will be modest. The third section of the paper describes this supply curve and some other wider implications of the simulations.

The Linkage of Alcohol and Agriculture

The connections between the grain alcohol industry and agriculture may be described in two ways. The demand for agricultural commodities will shift in terms of quantity as a function of the volume of alcohol output. Likewise, the cost of producing alcohol will depend on the price of agricultural commodities.

Physical Flows

Producing a gallon of alcohol requires 0.4 bushels of corn. So, we shall model the input for a fuel alcohol program as an outward shift in the demand curve for corn, a shift whose size is directly proportional to the size of the program. Distillation from corn yields marketable by-products, whose value reduces the cost of alcohol production by about one-fourth (Alston, p. 6; Office of Technology Assessment, pp. 11–12; Meekhof, Gill, Tyner, p. 15). Conventionally this by-product is a mash, which when dried is marketed as distillers dry grain (DDG). Production of a gallon of alcohol yields 6.8 pounds of DDG; as cattle fodder it will substitute for about 3.4 pounds of soybean meal. In order to save the cost of drying the mash into DDG, many

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plans call for using the mash wet in feedlots adjacent to distilleries. In either case, though, we can assume the same ratio of substitution between soybean meal and by-products per gallon of alcohol obtained by conventional dry milling. It is also possible to produce ethanol from corn by a wet milling process that yields corn oil and gluten meal as by-products (Alston, p.5). As DDG displaces some soybean meal in the fodder market, it will become desirable to have corn oil replace corresponding amounts of soybean oil. Therefore, a mix of the dry milling and wet milling processes probably will emerge. Because dry milling produces more alcohol per bushel of corn, and because soybeans are about four-fifths meal, dry milling will be the basis for the simulation here. The price of soybean meal per weight is just over four-fifths the price of soybeans. So a pound of DDG is equivalent to about two-fifths of a pound of soybeans, and each gallon of alcohol will yield by-products equivalent to about .045 bushels of soybeans.[1] We can, in short, model the impact of each billion gallons of alcohol production by shifting out the corn demand curve by 400 million bushels and shifting in the soybean demand curve by 45 million bushels.

Price Linkage

Both the input and output flows between alcohol distillation and agriculture contribute to the upward slope of the alcohol supply curve. Obviously, as increased alcohol production shifts out the demand curve for corn, the resulting higher price of corn will raise the cost of alcohol production. Increased alcohol production also would increase the supply and thus drive down the price of the by-products—DDG—and of the soybeans for which they substitute. Lower prices for by-products raise the total cost of the alcohol. With corn selling at \$3.70 per bushel in December 1980 and DDG at \$120 per ton (half the price of soybean meal) and with 20% inflation of Alston's estimate of other costs (\$.55/gal. in 1978 dollars, p. 6), ethanol would cost \$1.67 a gallon. Each percentage point rise in the price of corn would raise the cost of ethanol 0.85%, and each percentage point fall in the price of DDG would raise ethanol cost 0.25%.

Simulation with NIRAP

The National Interregional Agricultural Projection (NIRAP) system is a computerized simulation model of the U.S. agricultural sector. A model of this complexity is necessary because of the numerous interactions that would take place as alcohol production simultaneously increased the demand for corn and the supply of a soybean substitute (DDG). Marginal land would be drawn into corn cultivation. There would be substitutions in production as land was switched to corn from other crops, especially soybeans. There would be substitution in fodder usage, soybeans for corn. There would be substitution in animal raising and in meat consumption as animals needing relatively more soybeans (cattle) were substituted for those needing mostly corn (hogs and chickens). Exports would react to any changes in domestic prices. NIRAP incorporates these interactions into its simulations.

Simulations

For the principal set of simulations, alcohol fuel output was 10 billion gallons annually. This is an upper bound on eventual production levels, since it would almost suffice for gasohol completely to replace straight gasoline at current levels of use. Ten billion gallons of alcohol per year would require corn inputs equal to about half of current U.S. production. The structure of the NIRAP model is such that the effects of alcohol production are not exactly proportional to the volume of alcohol produced. So some results from simulations of 5 billion gallons of alcohol per year are reported to give the reader a sense of the nonlinearities.

Shifts in the export demand curves simulated the impact of a fuel alcohol program. The export demand curve for corn was shifted up by an amount corresponding to the input requirements for fuel alcohol production, and the export demand curve for soybeans was shifted down by an amount corresponding to the by-product output of 1979 and 1985. A longer phase-in period, 1979 to 1990, yielded similar results.

Measures of Impact

To measure the impact of grain ethanol production, the outcomes in various scenarios are compared with a base case in which there is no alcohol production and also no explicit government price support programs. The NIRAP projections include a rate of inflation, which is certainly realistic in general but is not likely to be precisely accurate in predicting price levels ten or twenty years hence. So, the differences between values in the base case and those in the simulated scenarios are reported as percentage changes from the base case value. Table 1 reports for several simulations the percentage changes in some of the key variables in agriculture.

For the purpose of estimating the slope of the ethanol supply curve, the changes in the price of corn and soybeans are most relevant.

For the purpose of understanding how the structure of agricultural production and consumption will change in response to large-scale ethanol production, we also want to look at changes in other key prices—wheat, beef, and pork. Even more revealing will be the changes in the production quantities of corn, soybeans, wheat, and meat, and in the amounts of these commodities that are exported.

[1] One gallon of ethanol yields 6.8 lb.DDG = 3.4 lb. soybean meal = 2.7 lb. soybeans = .045 bushels of soybeans.

Table 1. Projected Effects of Grain Alcohol Production on Selected Variables in the Agricultural Sector

Column		2	3	4	5	6	7
Alcohol output (billion gal./yr.)	5	10	10	10	10	10	10
Year	1990	1985	1990	2000	1985	1990	2000
Corn inputs (million bu./yr.)	2,000	4,000	4,000	4,000	4,000	4,000	4,000
By-product output (soybean equivalent million bu./yr.)	225	450	450	450	0	0	0
Percentage changes:[a]							
Corn — price	20.9	45.[illegible]	46.0	37.0	50.1	50.1	40.1
output	20.3	37.[illegible]	42.8	35.5	37.6	42.5	35.1
exports	−5.7	−8.[illegible]	−7.0	−5.7	−9.2	−7.2	−6.0
Soybeans — price	−5.4	−6.[illegible]	−9.8	−9.3	9.4	6.2	4.1
output	−9.1	−16.3	−17.0	−15.2	4.0	4.2	2.9
exports	4.6	9.[illegible]	10.1	8.1	2.2	1.9	0.9
Wheat — price	1.3	5.8	3.3	1.8	7.9	4.9	3.0
output	2.5	5.0	5.4	4.1	4.9	5.3	3.8
exports	1.3	3.2	3.0	2.0	2.8	2.6	1.5
Beef — price	−2.8	9.7	1.1	5.1	11.3	2.2	5.8
output	0.1	0.9	0.7	+0.0	0.7	0.4	−0.4
Pork — price	8.8	21.[illegible]	21.1	15.4	24.6	22.8	17.9
output	−2.3	−3.[illegible]	−4.0	−4.0	−3.7	−4.5	−4.6
Farm prices (aggreg. index)	3.6	11.[illegible]	8.3	5.9	14.1	10.5	7.4
Net farm income	7.7	32.[illegible]	18.3	11.4	41.2	23.6	14.3

[a] Compared to the base case projection with no alcohol production and no price supports. The percentage change was calculated as the difference from the base case divided by the value in the base case.

The ramifications of a fuel alcohol program for Americans' overall lifestyle show up in two variables. The changes in real net farm income show the benefits that will accrue to farmers. The changes in an index of average agricultural prices (paid to farmers) reveal the adverse impact on all consumers' budgets.

Results

The first 4 columns of table 1 show the projected values of key variables in simulations using the standard assumptions about input and output flows. Each billion gallons of alcohol requires 400 million bushels of corn and yields by-products that substitute for 45 million bushels of soybeans. The maximum levels of alcohol production—5 billion gallons annually for column 1 and 10 billion gallons for columns 2-4—are reached by 1985 and maintained thereafter.

Price Effects

Corn's price reacts most dramatically to alcohol production. Each additional billion gallons of alcohol per year raises the price of corn by about 4%. The relationship between alcohol production and corn price is linear in logarithms; each additional billion gallons of alcohol raises the natural logarithm of the corn price by the same amount. 0.038 in 1990. Alcohol production drives down soybean prices, as one would expect, because of the by-product DDG substituting for soybean meal. The relation for soybeans is complicated, however, by the substitution with corn in both production and consumption, induced by the strong rise in the price of corn. Still we can say that each additional billion gallons of alcohol production per year will lower the price of soybeans and their substitutes (DDG) on the order of 1%. This is not out of line with the findings of Meekhof, Tyner, and Holland, using a model with only corn and soybeans, that increasing ethanol production from 1 to 2 billion gallons would raise the price of corn 5.5% in the early 1980s and lower the price of soybeans 2%.

Alcohol production also affects prices of commodities not directly involved. Wheat prices would rise, but only about half a percent for every billion gallons of alcohol annually. Pork prices reflect the effects of higher feeding costs, with the percentage rise in projected pork prices being almost half as large as the percentage rise in corn prices. Beef prices react to at least three influences: high pork prices shift consumer demand toward beef; high corn prices raise the production cost of beef; and falling soybean prices lower costs. Because the last effect goes in the opposite direction from the first two and because the effects are nonlinear, beef prices fall for low levels of alcohol production and rise for high levels. The overall index of prices paid to farmers goes up a percentage point or less per

billion gallons of alcohol output. Although the effect on the overall consumer price index would be imperceptible, the rise in meat prices would be noticed and might arouse political opposition to gasohol subsidies.

Output Effects

Increased alcohol production would push up corn output almost as much as corn prices. The percentage of decline in soybean production is, on the other hand, around twice the percentage of decline in price. This happens because the increased availability of DDG shifts the soybean demand curve leftward, while the switching of land from soybeans to corn shifts the soybean supply curve also to the left. Wheat output increases in order to fill the increased need for corn substitutes. One can visualize the wheat-growing regions expanding slightly, perhaps at the expense of the corn-soybean regions, while the crop mix in corn-soybean regions shifts strongly toward corn.[2] The small change in projected beef production reflects that the price rise resulted from nearly equal upward shifts in its supply and demand curves. The decline in pork output, much smaller than the rise in price, confirms that the supply curve shifted up along a relatively static demand curve.

Exports

The major changes in exports, caused by alcohol production, are the decline of corn exports and rise of soybean exports. Wheat exports actually rise some, presumably to fill the gap in world markets left by the decline of corn exports. The net change in the trade balance would be positive, chiefly because of the higher corn prices.

Without By-Product Sales

One of the major uncertainties about large-scale grain ethanol production is how the corresponding large output of by-products will be marketable. In other words, will one billion bushels of DDG substitute for soybeans at the same ratio that 10 million bushels do at present? The scenarios discussed so far presume that they will. Realistically, one must expect some decline in the price of DDG and other alcohol by-products relative to the price of soybean products.

To see an extreme upper bound on the effect of diminishing opportunities for utilizing alcohol by-products, columns 5,6, and 7 of table 1 report results of a simulation where it was assumed that no alcohol by-products entered the agricultural economy. Except on soybeans, the effects in this no-by-product scenario, which has the same alcohol output as columns 2,3, and 4, do not differ much from the standard scenario. The prices of corn, wheat, beef, and pork rise a little more in the no-by-product scenario, and their outputs rise slightly less or, in the case of pork, fall slightly more. Net farm income rises about 30% more in the no-by-product scenario. The big change, of course, is for soybeans, whose price and output rise rather than fall.

Any other reasonable scenario for the prices and uses of by-products would yield results intermediate between those in columns 2–4 and those in columns 5–7.

Further Implications

The previous section reports the simulated effects of increased alcohol production on the prices and flows of commodities in the agricultural sector. These changes will have some broader ramifications for the supply price of ethanol, for the income of farm households, for the efficiency losses that our society would incur by subsidizing fuel alcohol, and for the moral issue of producing fuel from grain while millions of people in the world go hungry.

Ethanol Supply Curve

The long-run ethanol supply curve starts at a height approximately equal to its current cost, $1.67 per gallon, and slopes upward in accordance with the impact of ethanol production on agricultural prices. As described earlier, the cost of ethanol production rises 0.85% for each percentage point rise in the price of corn and 0.25% for each percentage point fall in the price of DDG. Each billion gallons of ethanol production will raise the price of corn 4% and lower the price of soybeans (DDG substitute) about 1%. The ethanol supply curve will, therefore, rise 3.65% for every billion gallons of ethanol. So producing 10 billion gallons of ethanol annually, the upper bound, would push its price up 36.5%, to around $2.30 per gallon in 1980 dollars.

Farm Incomes

How the gasohol program "plays in Peoria" and elsewhere in the rural Midwest depends chiefly on what it does to farm incomes—measured by "real net farm income" in the NIRAP model. Gasohol will be a political success with farm constituencies. In 1990, every additional billion gallons of alcohol annually would raise real net farm incomes by over 1.5%. The boost to net farm incomes from a given level of alcohol production appears to diminish over time. This occurs because land costs, which are netted out in the calculation of net farm income, rise in response to the greater demand for agricultural output. So if we count land rents as part of the profits of agriculture, rather than as part of the cost, then the supplement to farm income appears more accurately in the calculation for 1985: each billion

[2] The version of the NIRAP model that I used does not explicitly calculate the amount of land in cultivation.

gallons of annual alcohol production raises farm income by 2% to 3%.

As a policy to augment agricultural income, ethanol production subsidies should be compared with existing price support programs. To compare current crop diversion schemes with ethanol production, the NIRAP program was run with the constraint that government payments to farmers be sufficient to give the same net farm income as in the simulation for 10 billion gallons of ethanol production. The simulated necessary government outlays were 4.4% of potentially marketable output in 1985 6% in 1990, and 1.9% in 2000. Government payments were, in comparison, below 1% in the mid-1970s but over 6% in the late 1960s (USDA 1977, p 32).

Social Costs

Standard supply and demand analysis reveals the social cost of a fuel alcohol subsidy compared to a free market situation. The area under the fuel alcohol demand curve is the benefit to society from alcohol production—a gain divided between increased surplus for liquid fuel consumers and decreased resource costs of producing nonalcohol fuels. The area under the alcohol fuel supply curve is the resource cost of its production. So the social loss from a fuel alcohol subsidy is the area that is between the two curves, to the right of the equilibrium without a subsidy, and to the left of the equilibrium with a subsidy. When, as now, there would be virtually no fuel alcohol production without a subsidy, then the area of social loss is most of the value of the (implicit) government subsidy. The Schnittker Associates predict, however, that by 1985/86 the price of oil will have risen enough relative to the price of corn so that substantial amounts of fuel alcohol would be produced even without a subsidy (p. 44). In that event the social loss from the subsidy, if it remains, probably would be well under half the total value of the subsidy. In either case, the more responsive the agricultural sector, i.e., the more readily it diverts resources away from alternative uses and therefore the flatter the alcohol supply curve, the greater is the social cost arising from a given per gallon subsidy, and the smaller is the proportion of the subsidy that would be a pure transfer to the farmers' net income.[3] Clearly then, the implication of the NIRAP simulation, that the alcohol supply curve is relatively flat, means that the gasohol subsidy will be effective as an energy policy to reduce dependence on petroleum but will be a socially wasteful way to subsidize farm incomes

[3] See Webb (1981) for a fuller discussion. To the extent that present programs subsidize farm incomes by diverting some resources, e.g., land, from their highest valued uses, the social cost of replacing these programs with the fuel alcohol subsidy would be less than when compared with the free market situation.

Food versus Fuel

The moral question about producing fuel from resources that could feed hungry people is addressed most directly by looking at the changes in exports, especially of wheat. The main U.S. export that feeds the world's poor is wheat. Developing countries buy two-thirds of U.S. wheat exports and use them mostly for human consumption (USDA 1979, pp. 49–50). In the NIRAP simulations, fuel alcohol production actually caused wheat exports to increase Granted, the increased exports probably take the place of corn as fodder, but the wheat price rise is only 2% to 6% and so would do little to discourage human consumption.

Conclusions

The U S. agricultural economy as modeled in the NIRAP program appears to be capable of adjusting without major difficulties to even high levels of fuel alcohol production. The price of corn and cost of alcohol would rise significantly but not so high as to rule out the possibility of replacing with alcohol a tenth of current gasoline consumption. This prediction of great responsiveness by American agriculture is not surprising in view of its historical ability to adjust to shocks at least as large as those resulting from high levels of alcohol production. The extensiveness of the relationships modeled in NIRAP not only gives insights into the indirect effects of increased alcohol production but also probably accounts for why the direct effects are so mitigated.

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Impact of the Farmer-Owned Reserve on Privately Owned Wheat Stocks

Jerry A. Sharples and Forrest D. Holland

Peck and Gray, in a recent article, point out that private stockholding tends to be neglected in the literature on grain reserves. They emphasize that the relationship between publicly controlled reserves and privately owned stocks is crucial in determining the effectiveness of a grain reserve program. We agree. In this paper we further probe the private demand for wheat stocks. Now that three years' data are available on the U.S. farmer-owned reserve (FOR) it is possible to make an initial estimate of the impact of subsidized wheat reserves on privately owned wheat stocks.

Wheat started entering the FOR during the 1977/78 marketing year. The quantity in the reserve increased until January 1979, when 413 million bushels were accumulated. In May 1979, the wheat price reached the release level and farmers started withdrawing wheat from the reserve. One would expect that the reserve represented an additional demand for wheat during that time of accumulation raising the wheat price. But the price impact would depend upon the extent to which the wheat put into the reserve otherwise would not have been stored by farmers. We hypothesize that wheat stocks accumulated in the FOR partially substitute for wheat that otherwise would have been stored by farmers. If there is substitution, the effectiveness of the reserve as a price-moderating policy tool is reduced.

We have two purposes. First, to estimate the impact of the FOR on the demand for year-ending wheat stocks and second, to demonstrate the potential of a little-used functional form for estimating the demand for stocks.

The Model

The supply-of-storage theory is used in this paper to explain stockholders' behavior. From that theory we derive a demand-for-stocks function that relates current season wheat price with the quantity of carryover wheat stocks. The supply-of-storage theory has been discussed by Working and Labys and recently applied by Peck to the wheat market. The supply-of-storage theory postulates a positive relationship between the "price of storage" (a discounted, expected future price minus the current price) and the quantity stored. In this analysis the quantity of wheat, S, remaining in storage at the end of the marketing year is a function of expected return, $E(R)$, i.e.,

$$S = f[E(R)], \quad \text{where} \tag{1}$$

$$E(R)_t = P^*_{t+1} - P_t - C_t, \tag{2}$$

and P^*_{t+1} is expected wheat price the next year, P_t is wheat price in the current year, and C_t is the variable cost, including an interest charge, of storing one unit of wheat. For simplicity, it is assumed that there is no limit to storage space for wheat in the United States.

We postulate the relationship between stocks and expected return to be as shown in figure 1.[1] This relationship illustrates two purposes for holding stocks: for convenience (often called pipeline or working stocks) and for speculation. Pipeline stocks are held by processors and traders to enable them to utilize their plant and equipment and to facilitate trade. These stocks are normally hedged on the futures market, and the quantity held is not very responsive to changes in expected return from storage. Pipeline stocks are held even when expected return is negative. Most of the stocks shown in figure 1 with negative expected returns would be pipeline stocks.

Speculative stocks are held with the expectation of a positive return from storing wheat. Consequently, speculative stocks are very responsive to the level of expected return to storage. Most speculative stocks appear to be unhedged stocks owned by wheat producers.[2] For a large number of speculators with identical expected returns, the curve in figure 1 would be perfectly elastic at $E(R) = 0$. But in this case $E(R)$ represents an aggregate estimate of differing expected returns of

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[1] Strictly speaking, figure 1 does not show a supply-of-storage function since $E(R)$ contains both the price of storage and storage costs. However, figure 1 is useful for this analysis.

[2] A USDA survey showed that on 1 Jan. 1979, 50% of U.S. wheat stocks were stored off the farm but 62% of these off-farm stocks were owned by farmers. If it is assumed that all on-farm stocks are farmer-owned, then on 1 Jan. 1979, farmers owned 81% of U.S. wheat stocks. The same survey the two previous years showed similar results (reported in USDA, GrII-1 25 Jan. 1977 and 1 Feb. 1979).

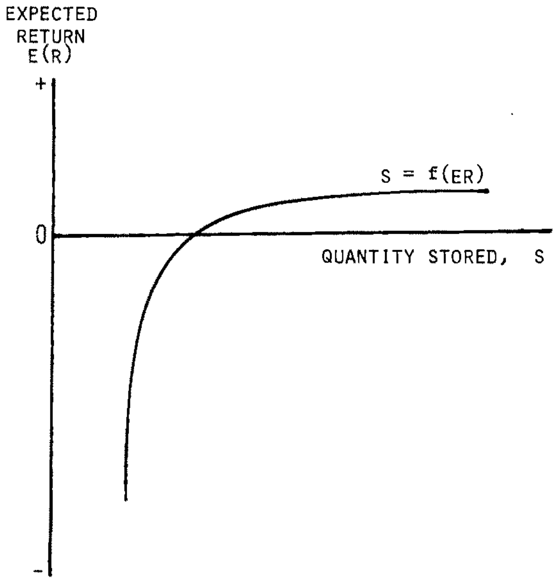

Figure 1. Hypothetical year-end stocks function

many speculators. Each speculator may have different values of P^*_{t+1}, C_t, and P_t. Thus, there is a positive slope to the curve for values of $E(R)$ near zero.

Substituting (2) into (1) gives

$$S_t = f(P^*_{t+1} - P_t - C_t). \tag{3}$$

This stocks function can be transformed into a stocks demand function (where S_t is a function of P_t) if values of expected price, P^*_{t+1}, and holding costs, C_t, are held constant. The relationship between S_t and P_t is expected to be negative. Given a price expectation for next year and a constant holding cost, as current price increases, expected returns from storing wheat decreases and thus the quantity stored decreases.

The relationship between the quantity of wheat stocks in the farmer-owned reserve and the wheat market price is difficult to handle in theory. This demand relationship is believed to be both discontinuous and nonsymmetrical. Two examples of modeling the demand for FOR stocks are presented in Bredahl, Meyers, and Womack and in Sharples. The purpose of this paper, however, is not to estimate participation in the FOR, but rather to estimate the impact of the FOR on the total quantity of stocks. Thus, FOR stocks are assumed exogenous in this analysis.

The FOR is a complicated program with many administrative provisions. For an explanation of the FOR, see Burnstein. The essence of the program, however, is to subsidize private stockholding when the wheat market price is below a specified release price. Thus, the FOR would be expected to increase private stocks, *ceteris paribus*. In this study the relationship between the FOR and the total stocks function is assumed to be simple:

$$S_t = f(P^*_{t+1} - P_t - C_t) + \gamma(FOR), \tag{4}$$

where S_t is privately owned year-end wheat stocks (including FOR stocks), and *FOR* is quantity of wheat stocks in the farmer-owned reserve. The value of γ is expected to be $0 < \gamma < 1$, i.e., a bushel added to the FOR increases total privately owned stocks by less than one bushel. If γ is near 1, the FOR program is effective in increasing total stocks. If γ is near zero, the FOR program is ineffective. The value of γ likely is not a constant; it probably is positively related with the size of the FOR and with price. But because there are only two positive observations for FOR in our data set, γ is assumed constant.

Estimation

In this section an estimate of equation (4) is obtained using annual data from 1972/73 to 1978/79. Wheat stock demand curves are derived from the estimated equation for ending stocks in 1977/78 and 1978/79. The impact of the FOR on the stock demand curves those years also is estimated.

Storage costs, C_t, in equation (4) are

$$C_t = I_tP_t + V_t, \tag{5}$$

where I_t is the interest rate, and V_t is the variable cost of storing a bushel of wheat.

A simple expectations model is used as a proxy for the aggregate of all wheat speculators' price expectations:

$$P^*_{t+1} = (P_t + P_{t-1} + P_{t-2}) \div 3. \tag{6}$$

This naive formulation assumes that speculators expect the price next year to be a simple average of the wheat price over the three most recent years.[3]

In order to incorporate several desirable properties, discussed below, the following functional form is used to represent the relationship between privately owned wheat stocks and expected return from storage:

$$S_t = \alpha[K - E(R)_t]^\beta + \gamma(FOR_t), \tag{7}$$

where K is an assigned constant, discussed below. The signs of α and β are expected to be positive and negative, respectively. Note in equation (7) that when the expected return approaches K, the value of S approaches infinity, and when $E(R)$ approaches negative infinity, S approaches zero. With the appropriate selection of K, equation (7) will approximate the form shown in figure 1. In order to prevent negative numbers from being raised to a

[3] More complex expectation models could have been used. The results indicate, however, that this naive model performs quite well. We also tried adjusting the prices in equation (6) for inflation. This expectation model gave a better estimate for 1979/80 stocks but over the fit period, it had a lower R^2.

negative power in equation (7) the value of K must be larger than the largest observed value of $E(R)$, i.e., .29 in 1976/77 (see table 1). Also, the level of K has an impact on the price elasticity of the stocks demand functions derived from equation (7). Relatively small values of K force the demand functions to be less elastic at high prices than at low prices—a condition expected by Hillman, Johnson, and Gray. Alternative values of K were tested and R^2 was maximized when $K = 0.6$, a value that met both of the above criteria.

Equation (7), with $K = 0.6$, is estimated using data for the seven marketing years 1972/73 to 1978/79 (table 1). 1972/73 appears to have been the beginning of a structurally changed wheat market. Exports dramatically increased that year to a higher sustained level. By the end of the year most CCC-owned wheat stocks were sold. Modeling this seven-year period is simplified because (*a*) the market price is always above the loan rate, so the influence of the price support feature of the wheat program is minimal; and (*b*) the inventory of CCC-owned wheat stocks is insignificant, thus their impact on private stockholding may be ignored.

The estimated stock supply function is[4]

$$(8)\quad S_t = 609(0.6 - E(R)_t)^{-.512} + .86(FOR_t),$$

where the adjusted $R^2 = .99$. The estimated stock function, assuming no farmer-owned reserve, is shown in figure 2. As can be seen by the R^2 value and the plots in figure 2, the equation fits the data well. The largest difference between the estimated and actual values is for 1973/74, where the equation overestimates the actual value by 29 million bushels (9%). Including the impact of the FOR stocks the last two years, the equation overestimates ending 1977/78 stocks by 3% and underestimates the 1978/79 stocks by 3%.

Equation (8) may be expanded to

$$(9)\quad S_t = 609\left[0.60 - \left(\frac{P_t + P_{t-1} + P_{t-2}}{3} - P_t - IP_t - V_t\right)\right]^{-.512} + .86(FOR_t).$$

Derived stocks demand functions are obtained for 1977/78 and 1978/79 by substituting values for lagged prices, interest, and variable storage costs into equation (9). These values are obtained from table 1. The resulting demand equations are

$$(10)\quad S_{77/78} = 609(.764P_{77/78} - 1.24)^{-.512} + .86(FOR_{77/78}),$$

$$(11)\quad S_{78/79} = 609(.755P_{78/79} - 0.82)^{-.512} + .86(FOR_{78/79}).$$

[4] The Time-Series Processor package was used on the CDC 6500. Standard errors for the estimated parameters were not obtained using the iterative least-squares technique.

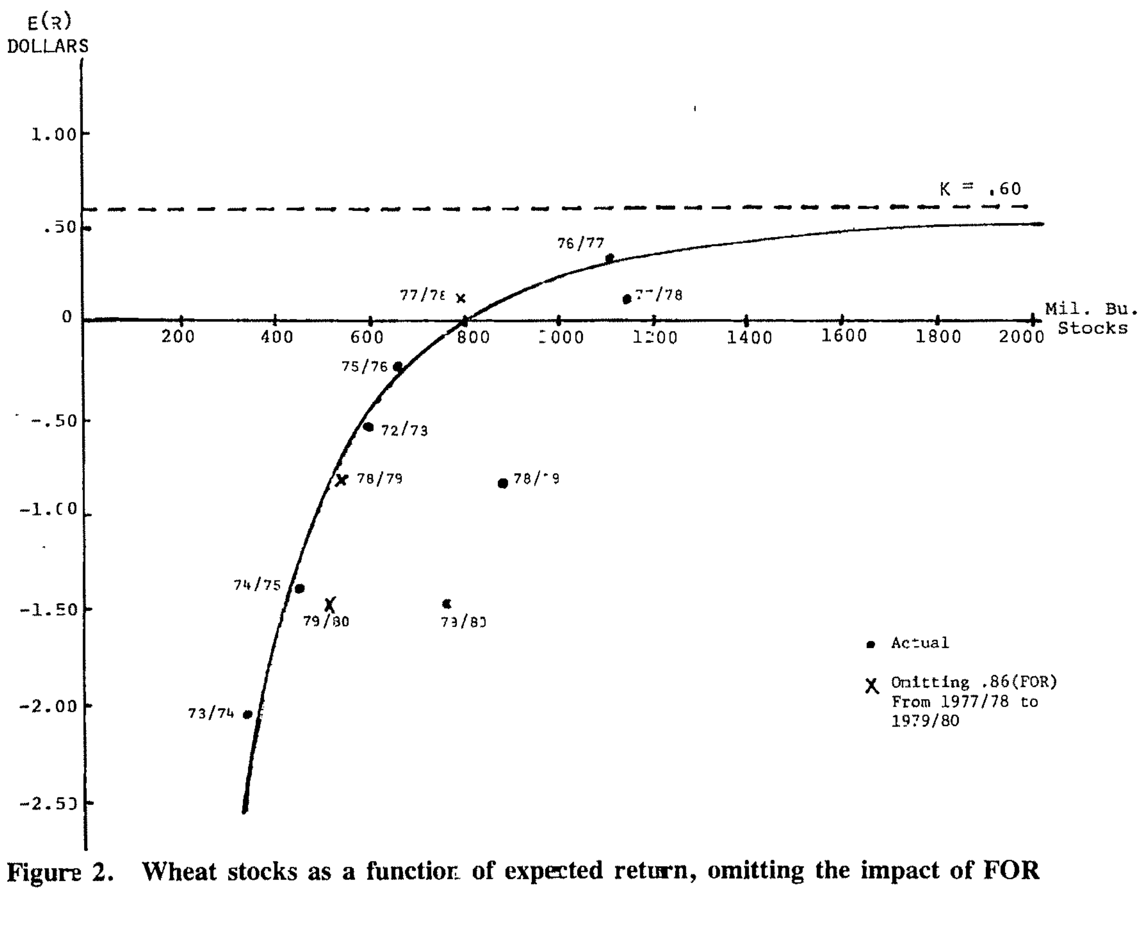

Figure 2. Wheat stocks as a function of expected return, omitting the impact of FOR

Table 1. U.S. Aggregate Data Used for Regression Analysis

Marketing Year	Year-End Wheat Stocks[a]	Season Average Wheat Price	Expected Price Next Year[b]	Storage Costs[c]	Interest Rate[d]	Expected Return from Storage[e]	Year-End FOR Stocks
	(Mil. bu.)	(Dol./bu.)	(Dol./bu.)	(Dol./bu.)	(Dol./bu.)	(Dol./bu.)	(Mil. bu.)
1970/71	—	1.33	—	—	—	—	—
1971/72	—	1.34	—	—	—	—	—
1972/73	591	1.76	1.48	.15	.070	−0.56	0
1973/74	339	3.95	2.35	.16	.081	−2.08	0
1974/75	435	4.09	3.27	.18	.094	−1.39	0
1975/76	665	3.56	3.87	.21	.089	−0.22	0
1976/77	1,112	2.73	3.46	.22	.082	0.29	0
1977/78	1,131	2.33	2.87	.26	.079	0.10	340
1978/79	875	2.98	2.68	.27	.088	−0.83	400
1979/80	761	3.82[f]	3.04	.29	.106	−1.47	250[f]

Sources: Stocks and prices, publications of USDA World Food and Agricultural Outlook Situation Board, ESS, and ASCS.
[a] Excludes CCC-owned stocks but includes FOR stocks and wheat under CCC loan, 31 May.
[b] Computed using equation (6) of the text.
[c] Based upon CCC storage rates.
[d] The average annual rate charged by Production Credit Associations (sources are table 683, *Agricultural Statistics, 1978* and p. 28, *Agricultural Finance Databook*, Aug. 1980).
[e] Expected price minus season average price minus storage costs; equation (2) of the text.
[f] Preliminary (Nov. 1980 USDA estimate).

Equations (10) and (11) are shown in figure 3 with the impact of the FOR omitted. These curves are estimates of what the stocks demand curves would have been without the FOR.

Assuming no FOR stocks, the stocks demand curve for 1978/79 lies to the left of the 1977/78 curve, and is less elastic (elasticities are given in table 2). This is so for two reasons. First, according to the simple price-expectations formula, speculators have lower expectations of future prices in 1978/79 than in 1977/78, for a given current price. For example, if the market price is \$3.00 in 1977/78, the price expected for 1978/79 by speculators in 1977/78 is $(3.00 + P_{t-1} + P_{t-2}) \div 3 = (3.00 + 2.73 + 3.56) \div 3 = \$3.10$. If the market price is \$3.00 in 1978/79, then speculators expect the price the following year to be $(3.00 + 2.33 + 2.73) \div 3 = \$2.69$. Second, costs of holding stocks are higher in 1978/79 than in 1977/78 because both the interest rate and variable storage costs increase (table 1).

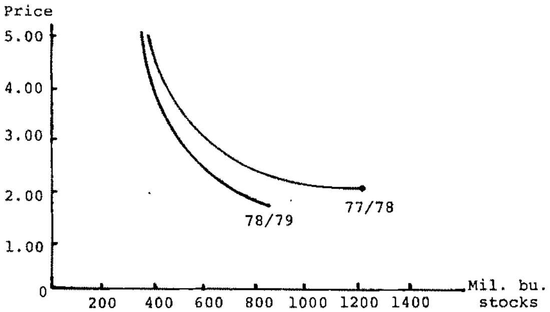

Figure 3. Demand for privately-held, year-end wheat stocks, 1977/78 and 1978/79, omitting impact of the FOR

The estimated value of γ in equation (7) indicates that privately owned wheat stocks increase .86 bushels for each bushel put into the FOR. This suggests that the FOR is effective in accomplishing one of its objectives—to increase stocks when the market price is below the release price.

The impact of the FOR on the wheat market may be illustrated for the 1977/78 marketing year assuming $\gamma = 0.86$. Without the FOR that year, the demand-for-private-stocks function would have shifted left by $(340 \times 0.86) = 292$ million bushels. This reduction in demand would have dropped the season average wheat price to the price support of \$2.25 per bushel.[5] If not supported, the price would have been lower. With the wheat price at \$2.25 rather than at \$2.33 in 1977/78, domestic use would have increased about 6 million bushels, exports would have increased 26 million bushels, and the net change in total stocks would have been an offsetting decrease of 32 million bushels. The price

[5] Price elasticity of demand is assumed to be −0.2 for domestic use and −.6 for exports. Elasticity of demand for stocks is obtained from the estimated equation (see table 2).

Table 2. Elasticity of Demand for Wheat Stocks at Selected Prices for Demand equations (10) and (11); *FOR* = 0

Price	Equation (10) 1977/78	Equation (11) 1978/79
5.00	−0.77	−0.65
4.00	−0.88	−0.70
3.00	−1.15	−0.80
2.00	−3.03	−1.12

Note: For the demand function of the form $S = L_0 + \alpha(L_1P - L_2)^{\beta}$, the price elasticity of demand is $\epsilon = \beta\alpha(L_1P - L_2)^{\beta-1}(L_1)(S^{-1})(P)$.

support program, in effect, makes the demand for stocks perfectly elastic at the wheat loan rate. It would have offset partially the stocks-reducing impact of not having the FOR in 1977/78.

The estimate of the impact of the FOR on private stocks is admittedly crude. Only two years' observations on the FOR are included in the data set. The estimate of γ captures the net effect of all exogenous shifters of the stock demand function those two years—not just the impact of the FOR. There are two reasons to believe that the value of γ overestimates the impact of the FOR. First, the wheat-marketing system had unusual difficulties in 1978/79 getting grain to terminal markets from early spring until after the end of the marketing year on 31 May. The Great Lakes opened late. Later, a major railroad serving wheat states was shut down These factors likely restricted marketings and increased ending stocks while only having a smal impact on season-average price. Second, the quantity of pipeline stocks may be positively related to the volume of wheat marketed. The average volume of wheat marketed during the two sample years containing the FOR exceeds the average of the sample years by 264 million bushels. The estimate of γ would capture this impact as well as the impact of the FOR. It is hypothesized that the two items listed above shifted the stocks demand function right during the sample years containing the FOR. If the hypothesis is true, the contribution to wheat stocks provided by the FOR is overestimated.

Equation (9) was used to estimate private stocks at the end of the 1979/80 marketing year using the data in table 1. The estimated value of 634 million bushels underestimates the preliminary actual value of 712 million bushels by 11%. The shock to the wheat market of the U.S.-Soviet trade suspension in January 1980 may have been a factor contributing to the underestimate.

Implications

The sample size and the degrees of freedom in this analysis are small, so the results must be viewed with some skepticism. Also the quantity of stocks held surely is determined simultaneously with other uses, price, and government action. The evidence, however, indicates that the FOR provided a substantial additional demand for wheat in 1977/78 and 1978/79—years when the FOR was being filled. The estimated value of γ in equation (7) is 0.86: one bushel of wheat placed in the FOR increases the total quantity of stocks demand by 0.86 bushels.

The supply-of-storage concepts used here appear to explain the wheat stockholding actions of private firms in recent years. Also, the functional form used for estimation has several useful attributes. First, it relates well to the hypothesized relation between stock size and expected net return to storage as drawn in figure 1. Second, the price elasticity along the demand curve changes as price changes. Specifically, it is possible for the elasticity to decrease as price increases—an attribute not associated with conventional demand equations. Third, it allows the demand curve to shift over time in response to changed price expectations as well as changed storage costs and interest rates.

As more data and experience with the FOR are obtained, a more thorough examination of the hypothesized relationship between the FOR and the demand for grain stocks may be done. One possibility for overcoming the small number of observations would be to use state data. With an expanded sample, several additional questions could be examined. Is γ in equation (7) positively correlated with price and the size of the FOR? What is the nature of the demand for stocks when price is above the FOR release level? What is the appropriate level of K in equation (7)? A test of the latter question would test the assertion by Hillman, Johnson, and Gray that the price elasticity of demand for privately owned stocks is less elastic at higher prices. This is a key issue when analyzing stability and grain reserves.

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Food Demand and Savings in a Complete, Extended, Linear Expenditure System

David B. Eastwood and John A. Craven

Demand equations derived from the classical, constrained, utility-maximization problem state that quantities demanded are functions of all prices and income. An implication is that consumer purchase decisions are interrelated and should be viewed from a systems context. Recent economic events have focused attention on the high prices of energy, medical services, food, and housing, as well as the low level of consumer savings. Such concerns make it desirable that we have estimates of a set of parameters which will allow inferences to be made about the probable response of food demand and savings to changes in consumer income and a comprehensive set of consumer prices.

The purpose of this note is to present and compare the parameter estimates and systems projections obtained from two alternative formulations of Lluch's extended linear expenditure system (ELES). Savings is explicitly introduced into both variants by the constrained maximization procedure. From a practical viewpoint, we delineate a set of demand categories which we feel are more relevant to the study of current economic problems than those used in most published studies.

The Model

Lluch develops the ELES via the constrained maximization of an intertemporal Klein-Rubin utility function subject to a budget constraint in which personal income is the limiting exogenous variable.[1] Howe, by making a simple assumption about the savings behavior of consumers, has shown that the ELES also can be obtained through the constrained maximization of a static Klein-Rubin utility function.[2] Howe's approach is outlined below.

Assume in each time period that (a) a consumer's preference ordering can be represented by the Klein-Rubin utility function, and that (b) he allocates income among n consumption categories and an $(n+1)$th category that is savings. Stated in mathematical terms, the consumer's maximization problem is as follows:

$$\text{(1)} \qquad \text{maximize } U = \sum_{i=1}^{n+1} \beta_i \log (x_i - \gamma_i),$$

$$\text{(2)} \qquad \text{subject to } \sum_{i=1}^{n+1} p_i x_i = y,$$

where U is utility, the x's are quantities, the p's are prices, y is income, the β_i and γ_i are parameters, and the subscript refers to a specific commodity. By assuming that the γ for savings, S, is zero, Howe obtains the demand and savings equations of the system which are identical to those of Lluch:

$$\text{(3a)} \qquad x_i = \gamma_i + (\beta_i/p_i)(y - \sum_{j=1}^{n} p_j\gamma_j), \text{ and}$$

$$\text{(3b)} \qquad S = p_{n+1}x_{n+1} = \beta_{n+1}(y - \sum_{j=1}^{n} p_j\gamma_j).$$

Within the ELES, the demand for a commodity is composed of two parts. The first part (γ_i) is an amount which the consumer perceives as a "minimum requirement" or "habit persistence" quantity.[3] The second component consists of a proportion (β_i/p_i) of the income left after accounting for all expenditures on the habit persistence quantities. This income component is called "supernumerary" or "surplus" income. β_i is the marginal expenditure on the ith commodity, given a small change in income. Thus, depending upon the equation, β_i can be interpreted either as the marginal propensity to consume good i or the marginal propensity to save.

Ordinary price elasticity formulas are as follows:

Own Price

$$\varepsilon_{ii} = -1 + (1 - \beta_i)(\gamma_i/x_i)$$

Cross Price

$$\varepsilon_{ij} = -\beta_i(p_j\gamma_j/p_ix_i)$$

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Views expressed do not necessarily reflect those of the USDA.

[1] Our model development is, of necessity, brief. The reader who is not familiar with the properties of complete demand systems in general, or the extended linear expenditure system in particular, can find an excellent discussion in Phlips.

[2] Both formulations are "extensions" of Stone's linear expenditure system (LES). They are extensions in the sense that savings are determined as an endogenous component in the model.

[3] Thus, Howe's assumption is that the minimum required quantity of savings is zero. The minimum requirement interpretation of the γ parameters is attributable to Samuelson.

The income elasticity formula is β_i/w_i, where w_i is the average budget share defined as p_ix_i/y. All variables are referenced at the current time period.

Variants of the ELES can be obtained by specifying alternative functional forms for the parameters. In addition to the form (3) which assumes constant values for the parameters, we specify a model in which the habit persistence parameters are assumed to be direct proportions of the previous period's consumption ($\gamma_i = \alpha_i x_{it-1}$).[4] For discussion purposes, we identify this model as ELESH. The solution of the ELESH utility maximization problem yields equations which are the same as time-subscripting the variables in (3a) and (3b) and substituting the proportional habit persistence formula for the γ_i's and γ_j's. We assume the marginal expenditure shares to be constant in both models.[5]

Properties of the Model

An advantage of specifying a particular utility function is that the theoretical properties of homogeneity, symmetry, and adding-up are automatically satisfied at each set of data coordinates. A disadvantage is that the properties inherent in the choice of a particular utility function may prove to be unduly restrictive. The Klein-Rubin utility function belongs to the additive class of utility functions—the marginal utility of each commodity is assumed to be independent of the level of consumption of all other commodities. Other implications inherent in this choice are that (*a*) $(x_i - \gamma_i) > 0$ for all observations, (*b*) $\beta_i > 0$ (no inferior goods), (*c*) $\sum_{i=1}^{n+1} \beta_i = 1$, (*d*) all goods must be substitutes, and (*e*) all price elasticities must lie within the range of zero and minus one. Thus, care must be taken to select commodities thought to possess these properties if the analysis is to be meaningful.

Procedure

Each model consists of twelve equations, eleven of which are consumption equations. Savings comprises the twelfth. Consumption categories are food-at-home, food-away-from-home, alcohol-tobacco, clothing, housing, utilities, transportation, medical, durables, nondurables, and "other" services. Major differences between our groupings and those contained in most published studies are the separation of the food component into at-home and away-from-home categories, the exclusion of alcohol from the food categories, the delineation of medical expenses into a separate category, and the transfer of automobiles from the transportation category into the durables category. A detailed composition of our demand categories can be found in Mann.

Data

Requisite data include quantities consumed, prices, and personal income. Our data source for the quantities and prices was the U.S. Department of Commerce's annual series on personal consumption expenditures. Quantities consumed were represented by personal consumption expenditures measured in constant (1972) dollars.[6] Our price data are implicit prices calculated as the ratio of personal consumption expenditures measured in current dollars to personal consumption expenditures measured in constant dollars. Income was measured as the sum of personal consumption expenditure on the eleven categories plus personal savings. Personal savings data were obtained from various issues of the *Survey of Current Business*.[7] All quantity and income data were placed on a per capita basis. Population data are midyear resident population figures obtained from *Population Estimates and Projections*.

We chose the 1955–78 time period for analysis. Considerations reflected in this choice include the desire to eliminate war years from the analysis and the recognition that the assumption of fixed-parameter values is probably suitable only for short time periods.

Parameter Estimation

In order to obtain parameter estimates, we used a nonlinear multivariate maximum-likelihood procedure developed and programmed by Snella (1979). Operationally, we appended an additive error term to the demand equations (3a) and estimated the parameters directly. The parameter of the savings equation (3b) was obtained by the property that the sum of the individual marginal propensities to consume plus the marginal propensity to save must equal one.

For the error specification, we assumed that $\mathbf{v}_t = \rho\mathbf{v}_{t-1} + \mathbf{e}_t$ where $\mathbf{v}_t$ is a vector of error terms and ρ is a common parameter for all equations. The vector $\mathbf{e}_t$ is assumed to have the following properties: $E(\mathbf{e}_t)$

[4] Our reason for specifying this model is that Pollak and Wales found this to be a particularly suitable hypothesis for the LES. To our knowledge, ELESH parameter estimates for the U.S. have not been published previously.

[5] Snella (1978) estimates a model for Norway in which the marginal expenditure shares are assumed to be functions of total expenditure. His assumption eliminates the linearity of the Engel curves assumed in (3). He concludes that "the hypothesis of constant uncommitted budget shares is not at all an implausible one, at least for the period of time analysed" (p. 297). We proceed under the assumption of constant marginal expenditure shares and, hopefully, minimize any misspecification by analyzing as short a time period as possible.

[6] These were aggregated from a detailed computer tape. The tape was obtained from Computer Systems and Services Division; Bureau of Economic Analysis; U.S. Department of Commerce.

[7] It should be pointed out that the sum of personal consumption expenditures on our eleven categories do not sum to "Total PCE" as reported in *Survey of Current Business*. We omit several reported items which do not pass through the marketplace. These are also detailed in Mann.

$= 0$, $E(e_t \mathbf{M}'_\tau) = 0$, all $\tau > t$; $E(\mathbf{e}_t \mathbf{e}'_\tau) = \delta_{t\tau}\Omega$, all t, all τ; $r(\Omega) = n$. Here E is the expectation operator, M is a vector of prices and income, δ is Kronecker's delta, r indicates the rank of a matrix, the prime indicates transposition, and the subscripts refer to a particular time period. The β, γ, and α values were not constrained to remain within the range of the a priori values.

Results

Parameter estimates for each system are presented in table 1. Each system solution is characterized by relatively high R^2 values and, in general, relatively small asymptotic standard errors for their estimated coefficients. Inspection of the table reveals that the estimated β values change according to model specification. The most pronounced changes are for the housing, medical, durables, "other" services, and savings categories. In general, the ELESH model allocates a larger proportion of surplus income to durables and savings—a smaller proportion is allocated to each of the remaining categories.

Associated with the small ELESH β estimates for housing and medical are α estimates, which exceed unity. This result gives rise to instability problems when the system is analyzed within a dynamic context. For these categories, the hypotheses $\beta_i = 0$, and $\alpha_i = 1$ cannot be rejected at the 10% level. The negative value for the medical β estimate is associated with habit persistence quantities which exceed actual consumption in all but two sample years. In part, these results may reflect some data peculiarities. The housing estimates may be affected by the inclusion of the imputed value of owner-occupied housing, which is contained in the national accounts. The medical category underwent very pronounced changes over the time period—its quantity increased in excess of 250% and its implicit price increased approximately 300%.

Further insight regarding the differences between the two forms can be obtained from inspection of table 2. Both models fit the data well overall, so it is not surprising to observe the similarity between the predicted expenditure columns. However, the surplus income columns show a marked discrepancy. As a percentage of income, the surplus increases from 21.6% in 1955 to 54.3% in 1978 for the ELES; whereas, the corresponding figures for the ELESH are, respectively, 24.5 and 22.9. Relative to income, the ELESH form has the surplus falling because consumers are increasing their habit persistence quantities. This is consistent with the notion people have of a rising standard of living while at the same time not feeling any better off.

Table 1. Estimated Parameters of the ELES and ELESH

	ELES			ELESH		
Category	β	γ	R^2	β	α	R^2
Food-at-home	.04931 (.01121)[a]	391.745 (20.162)	.[illegible]274	.04277 (.01748)	.93904 (.02951)	.8844
Food-away-from-home	.02823 (.00409)	95.453 (7.580)	.[illegible]589	.02336 (.00726)	.87558 (.04689)	.9571
Alcohol-tobacco	.01653 (.00222)	128.773 (4.595)	.9543	.01466 (.00303)	.93232 (.01549)	.9360
Clothing	.07483 (.00481)	188.69[illegible] (13.257)	.9911	.06734 (.00932)	.84264 (.02638)	.9859
Housing	.14237 (.00823)	270.227 (20.986)	.9937	.01245 (.00773)	1.01885 (.01419)	.9993
Utilities	.03295 (.00241)	68.731 (4.326)	.9988	.02612 (.00434)	.85035 (.03109)	.9839
Transportation	.06779 (.00478)	157.132 (10.773)	.9901	.04054 (.00455)	.90034 (.01875)	.9963
Medical	.10843 (.00905)	106.990 (19.576)	.9971	−.00136 (.00598)	1.04413 (.01952)	.9959
Durables	.19445 (.02001)	134.220 (46.960)	.9[illegible]96	.38932 (.02419)	.27856 (.09279)	.9812
Nondurables	.05690 (.00557)	91.724 (12.289)	.9[illegible]91	.03956 (.00837)	.84901 (.04142)	.9843
Services	.09300 (.00630)	249.556 (16.301)	.9[illegible]5	.05507 (.01476)	.90367 (.03639)	.9923
Savings	.13521			.29017		
ρ (Autocorrelation coefficient)	.81300 (.035)			.20585 (.05955)		

[a] Standard errors are in parentheses.

Table 2. Income, Savings, Projected Expenditure and Savings, and Surplus Incomes per Capita

	Actual		ELES			ELESH		
Year	Income	*S*	Expenditure	*S*	Surplus	Expenditure	*S*	Surplus
1955	1,545.293	90.265	1,450.493	94.800	334.212	1,434.327	110.966	378.945
1956	1,614.803	116.974	1,526.427	88.376	378.830	1,508.356	106.447	381.020
1957	1,671.318	120.120	1,562.900	108.418	395.332	1,560.802	110.516	375.974
1958	1,696.834	124.531	1,588.042	108.792	389.752	1,590.018	106.816	360.103
1959	1,766.630	106.190	1,647.640	118.990	439.502	1,643.477	123.153	409.673
1960	1,804.105	94.822	1,703.926	100.179	451.027	1,698.451	105.654	373.211
1961	1,843.714	110.229	1,751.489	92.225	474.900	1,736.804	106.910	378.051
1962	1,920.467	109.786	1,810.379	110.088	533.951	1,798.087	122.380	421.337
1963	1,981.664	99.712	1,872.951	108.713	575.284	1,861.870	119.794	421.716
1964	2,121.538	136.716	2,009.277	112.261	696.792	1,978.508	143.030	509.097
1965	2,262.409	156.444	2,116.997	145.412	812.967	2,102.866	159.543	557.808
1966	2,418.778	168.732	2,254.521	164.257	924.974	2,247.226	171.552	595.217
1967	2,552.920	206.977	2,377.729	175.191	1,023.912	2,375.477	177.443	614.294
1968	2,732.661	190.929	2,520.549	212.112	1,142.758	2,529.939	202.722	677.382
1969	2,897.227	174.338	2,699.234	197.993	1,233.904	2,704.391	192.836	668.615
1970	3,118.296	248.143	2,925.805	192.491	1,374.371	2,912.940	205.356	721.971
1971	3,346.656	278.034	3,086.528	260.128	1,530.135	3,103.210	243.446	810.337
1972	3,571.314	237.089	3,283.415	287.899	1,688.064	3,303.361	267.953	891.670
1973	4,008.406	346.294	3,729.532	278.874	2,004.340	3,709.809	299.597	1,047.367
1974	4,332.086	338.963	3,980.095	351.991	2,098.669	4,051.863	280.223	930.821
1975	4,753.480	392.619	4,388.223	365.257	2,347.403	4,419.816	333.664	1,096.608
1976	5,142.855	319.489	4,725.094	417.761	2,625.536	4,763.934	378.921	1,249.893
1977	5,615.562	298.984	5,247.648	367.914	2,961.723	5,245.797	369.765	1,306.493
1978	6,221.668	330.305	5,854.598	367.070	3,375.507	5,826.285	395.383	1,423.346

Predicted savings in both models provide fairly close approximations of actual savings, and examination of the data provides some basis for ELESH being superior. Of the twelve actual turning points, ELES correctly predicts four; whereas, ELESH correctly predicts seven. ELESH's predicted savings values are closer to the actual values in thirteen of the twenty-four years. Unfortunately, both models greatly overpredict savings in the last three years.

Focusing on the food demand equations, the systems imply different patterns for the habit persistence quantities. The ELES γ estimate for food-at-home was 96% of consumption in 1955 and trended downward to 78% in 1978. For the ELESH the corresponding figures were 91% and 95%, respectively, with no discernable trend. A similar pattern was observed for the food-away-from-home habit-persistence quantities expressed as a percentage of consumption. For the ELES, this was 82% in 1955 and trended to 60% in 1978. For the ELESH, the corresponding figures are approximately 87% for both years.

System projections for the food demand categories, along with their observed values, are presented in table 3. The ELES appears to project food demand better than does the ELESH. The ELES projects the magnitude of demand for food-at-home better than the ELESH for fourteen out of the twenty-four sample years. ELES also identifies four out of nine turning points versus two for

Table 3. Food at Home and Food Away from Home: Actual Observations and System Projections

	Food-at-Home			Food-Away-from-Home		
Year	Actual	ELES	ELESH	Actual	ELES	ELESH
1955	406.3	401.6	395.2	116.8	118.2	117.4
1956	414.4	411.3	408.2	118.0	118.0	118.2
1957	419.3	415.6	414.0	116.6	117.5	118.6
1958	415.7	417.8	416.4	112.4	115.5	116.0
1959	427.1	420.0	415.1	114.5	114.6	113.5
1960	424.1	426.6	425.6	116.8	114.8	114.4
1961	421.8	425.2	420.7	118.8	117.3	116.8
1962	416.9	425.9	420.9	122.1	120.4	119.7
1963	413.0	421.1	414.9	124.6	122.7	122.4
1964	424.2	423.4	416.0	128.4	128.4	127.3
1965	440.2	433.0	430.7	130.7	131.8	131.6
1966	448.7	445.0	446.8	130.0	133.1	133.5
1967	456.7	454.7	454.5	126.6	132.2	132.0
1968	469.6	461.0	463.9	132.8	130.2	129.3
1969	473.1	469.6	474.7	133.0	134.0	135.1
1970	481.3	474.8	477.4	132.9	135.2	134.6
1971	479.0	484.9	489.4	130.3	136.3	135.6
1972	479.1	481.1	486.0	134.7	134.9	133.7
1973	461.3	480.7	486.8	139.6	140.8	140.5
1974	443.6	455.0	456.9	139.2	137.6	139.9
1975	449.1	451.2	444.8	144.9	141.6	141.0
1976	473.7	461.9	458.1	152.1	147.5	148.3
1977	488.8	482.5	484.6	157.9	154.3	154.4
1978	484.0	491.6	496.6	159.9	159.1	159.4

Table 4. Uncompensated Price, Expenditure, and Income Elasticities: ELES and ELESH Computed for 1978

	Food-at-Home	Food Away	Alcohol-Tobacco	Clothing	Housing	Utilities	Transportation	Medical	Durables	Nondurables	Services	Expenditures	Income
Food-at-home	−.2306[a]	−.0095	−.0103	−.0145	−.0225	−.0082	−.0153	−.0108	−.0111	−.0084	−.0214	.3559	.3759
	[−.0923]	[−.0119]	[−.0109]	[−.0203]	[−.0458]	[−.0114]	[−.0228]	[−.0315]	[−.0114]	[−.0137]	[−.0312]	[.3087]	[.3260]
Food-away-from home	−.0711	−.4198	−.0184	−.0259	−.0400	−.0146	−.0273	−.0192	−.0198	−.0150	−.0382	.6342	.6697
	[−.0689]	[−.1557]	[−.0185]	[−.0346]	[−.0779]	[−.0193]	[−.0388]	[−.0535]	[−.0193]	[−.0233]	[−.0531]	[.5248]	[.5542]
Alcohol-tobacco	−.0487	−.0116	−.2505	−.0177	−.0274	−.0100	−.0187	−.0132	−.0136	−.0103	−.0262	.4347	.4591
	[−.0507]	[.0148]	[.0869]	[−.0234]	[−.0572]	[−.0142]	[−.0285]	[−.0393]	[−.0142]	[−.0171]	[−.0390]	[.3855]	[.4072]
Clothing	−.1002	−.0238	−.0259	−.5491	−.0564	−.0206	−.0384	−.0270	−.0280	−.0212	−.0538	.8938	.9439
	[−.1057]	[−.0310]	[−.0283]	[−.2663]	[−.1194]	[−.0296]	[−.0595]	[−.0820]	[−.0296]	[−.0357]	[−.0813]	[.8043]	[.8494
Housing	−.1041	−.0247	−.0269	−.0379	−.6470	−.0213	−.0399	−.0281	.0300	.0220	.0559	.9280	.9800
	[−.0107]	[−.0031]	[−.0029]	[−.0053]	[−.0444]	[−.0030]	[−.0060]	[−.0083]	[−.0030]	[−.0036]	[−.0082]	[.0812]	[.0857]
Utilities	−.0839	−.0199	−.0217	−.0305	−.0472	−.4949	−.0322	−.0226	−.0234	−.0177	−.0450	.7483	.7903
	[−.0779]	[−.0228]	[−.0209]	[−.0391]	[−.0881]	[−.1855]	[−.0439]	[−.0605]	[−.0218]	[−.0263]	[−.0600]	[.5932]	[.6264]
Transportation	−.0883	−.0209	−.0228	−.0321	−.0497	.0181	[illegible]	.0118	.0316	.0107	.0474	.7876	.8320
	[−.0019]	[−.0181]	[−.0166]	[−.0310]	[−.0699]	[−.0174]	[−.1755]	[−.0480]	[−.0174]	[−.0209]	[−.0476]	[.4711]	[.4976]
Medical	−.1213	−.0288	−.0314	−.0441	−.0683	−.0249	−.0465	−.7309	−.0339	−.0257	−.0651	1.0820	1.1426
	[.0018]	[.0005]	[.0005]	[.0009]	[.0021]	[.0005]	[.0010]	[.0190]	[.0005]	[.0006]	[.0014]	[−.0140]	[−.0148]
Durables	−.1571	−.0372	−.0406	−.0572	−.0885	−.0322	−.0603	−.0424	−.8184	−.0332	−.0843	1.4009	1.4794
	[−.3685]	[−.1079]	[−.0988]	[−.1847]	[−.4164]	[−.1033]	[−.2074]	[−.2860]	[−.8380]	[−.1244]	[−.2836]	[2.8047]	[2.9620]
Nondurables	−.1156	−.0274	−.0299	−.0421	−.0651	−.0237	−.0443	−.0312	−.0323	−.5948	−.0621	1.0308	1.0886
	[−.0942]	[−.0276]	[−.0253]	[−.0472]	[−.1064]	[−.0264]	[−.0530]	[−.0731]	[−.0264]	[−.2284]	[−.0725]	[.7167]	[.7569]
Services	−.0888	−.0210	−.0229	−.0323	−.0500	−.0182	−.0341	−.0240	−.0248	−.0188	−.5352	.7917	.8360
	[−.0616]	[−.0180]	[−.0165]	[−.0309]	[−.0696]	[−.0173]	[−.0347]	[−.0478]	[−.0173]	[−.0208]	[−.1866]	[.4688]	[.4951]
Savings	−.1957	−.0464	−.0506	−.0712	−.1102	−.0401	−.0751	−.0528	−.0546	−.0414	−.1051		1.8432
	[−.5438]	[−.1593]	[−.1458]	[−.2726]	[−.6145]	[−.1524]	[−.3060]	[−.4221]	[−.1524]	[−.1835]	[−.4186]		[4.3712]

[a] ELESH computations are bracketed; ELES are placed above.

ELESH. For food-away-from-home, both systems identify four out of eight turning points, but the ELES projects the quantity demanded better in the early years.

Uncompensated price, total expenditure, and income elasticities for the two models are presented in table 4. There are too many to discuss individually. Starting with the ELES values, the own-price elasticities for food-at-home, and alcohol and tobacco are the most inelastic. The demand for food-away-from-home is more sensitive to its price than food-at-home, which is consistent with the latter being more a necessity. Durables has the elasticity closest to −1. Four luxury goods are indicated by the income elasticities (medical, durables, nondurables, and savings). The demand for food-at-home appears to be the least sensitive to other prices as the uncompensated cross-price elasticities of the first row are the closest to zero of all the rows. Food-at-home prices have the largest effects on the quantities demanded of the other goods. This is indicated by the uncompensated cross-price elasticities of the first column, which are the smallest of the columns. The food-at-home price is observed also to have the largest impact on savings.

The ELESH model has elasticities which indicate somewhat different responses. All of the own-price elasticities are more inelastic than their ELES counterparts, thereby indicating less own-price sensitivity. Housing now is the most inelastic, followed by alcohol and tobacco and food-at-home. This is consistent with the smaller increases in ELESH surplus income. Most of the current period's income in ELESH is used as habit persistence. Uncompensated cross-price elasticities do not display uniform change vis-à-vis those of the ELES, but within the ELESH a pattern similar to that of ELES emerges. The cross-price elasticities of housing are now the lowest, followed by food-at-home. The food-at-home column, except for housing, is the smallest. There are only two luxuries in ELESH. They are durables and savings.

Summary

Two forms of the extended linear expenditure system were estimated. Both include savings as a budget category so that consumer responses can be analyzed across the entire spectrum of decision making. Other features of the study are (*a*) the delineated demand categories differ from those traditionally used, and, we feel, are more relevant to the study of current economic problems, (*b*) ELESH parameter estimates for the United States have not been published previously, and (*c*) the models account for first-order autocorrelation.

The model form was found to have important implications for the analysis of consumer responses. Surplus income rose dramatically in ELES; whereas, it actually declined as a percentage of disposable income in ELESH. The latter is more consistent with the phenomenon of consumers experiencing a rising standard of living but not really feeling better off. Both models predict savings well, but ELESH has a small advantage overall. ELES projects food demand better then ELESH. This suggests that, for the food categories, the fixed-habits assumption is more plausible than the adaptive habits hypothesis.

Larger income elasticities are obtained for ELES. Except for durables, ELESH own-price elasticities lie closer to zero than those for ELES. This suggests that for ELESH, consumer demand is less responsive to own-price changes. It is due, in part, to the lower values obtained for the ELESH marginal budget shares, but the major part is due to the higher levels of habit persistence quantities in ELESH. The cross-price elasticities suggest that, *ceteris paribus*, a change in the price of food-at-home has larger percentage effects on the quantities demanded in the other categories than vice versa.

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Evaluating Price Stabilization Schemes with Mathematical Programming

Peter B. R. Hazell and Carlos Pomareda

Price stabilization schemes for risky agricultural markets continue to attract interest. Applied welfare economics has offered some insights into who gains from stabilization (Turnovsky). Economic models, such as stochastic simulation and dynamic programming, have been used to evaluate the costs of alternative stock sizes and storage rules (Reutlinger; Burt, Koo, Dudley).

A limitation of these analytical approaches is their difficulty in dealing with substitutes on the demand side and/or competition for scarce resources with other commodities in production. Stabilization interventions in any one market may have important spillover effects in other markets that are not captured in the usual single-commodity framework. In addition, even though the importance of producers aversion to price and yield risks has been recognized as a determinant of supply (Just), the implied changes in average supply following price stabilization typically are ignored. Also, nearly all the analytical work on price stabilization has focused on a very narrow set of policy objectives, particularly the changes in producers' and consumers' surplus, producers' income, and storage costs. However, price stabilization may affect a wider range of policy issues when allowance is made for risk response and multimarket interactions.

Price-endogenous mathematical programming models can take account of multiproduct relationships in supply and demand and can simulate the effects of risk-averse behavior at the farm level. They also can provide a wealth of detailed information about production, resource use, consumption, prices, and trade, at both the micro (farm or regional) and sectorwide levels. This paper shows how a class of price-endogenous mathematical programming models that assume integrability of product demands can be used to evaluate price stabilization schemes.[1] The method is illustrated by using an agricultural sector model of Guatemala to evaluate a hypothetical bean price stabilization scheme.

An Agricultural Sector Model of Guatemala

The Guatemalan model used here is typical of the price-endogenous mathematical programming models recently reviewed by McCarl and Spreen. In particular, the model has a linear and integrable demand system, a linear constraint set, and a risk behavior specification of the mean standard deviation type. The model is fully described in Pomareda. The purposes here are simply to establish notation and to review those model features necessary for discussing some price stabilization experiments.

Let the domestic demand system be $\mathbf{P} = \mathbf{A} - \mathbf{B}\mathbf{P}$, where $\mathbf{P}$ and $\mathbf{Q}$ are $n \times 1$ vectors of domestic prices and market supplies, respectively, and $\mathbf{A}$ and $\mathbf{B}$ are $n \times 1$ and $n \times n$ matrices of demand coefficients. For notational simplicity we ignore representative farm subscripts and assume international trade in all commodities. In fact, trade activities are included in the model only to permit food crop imports and nonfood crop exports. These restrictions closely approximate past Guatemalan trade policies, and can lead to important differences between domestic and world prices.

The model objective function that provides the competitive solution to prices and quantities in all markets is:

$$(1)\quad \text{MAX } \Phi = E(\mathbf{Q}')\,[\mathbf{A} - \tfrac{1}{2}\,\mathbf{B}E(\mathbf{Q})] - \mathbf{C}'_x\mathbf{X} + \mathbf{C}'_r\mathbf{R} - \mathbf{C}'_m\mathbf{M} - k(X'\Omega\mathbf{X})^{\frac{1}{2}},$$

where $E(\mathbf{Q}) = E(\mathbf{N})\mathbf{X} + \mathbf{M} - \mathbf{R}$, and $\mathbf{X}$ is an $n \times 1$ vector of crop acreages grown; $\mathbf{N}$ is an $n \times n$ diagonal matrix of stochastic per acre yields; $\mathbf{M}$ and $\mathbf{R}$ are $n \times 1$ vectors of tons of imports and exports, respectively; $\mathbf{C}_x$ is an $n \times 1$ vector of production costs per acre; $\mathbf{C}_m$ is an $n \times 1$ vector of import costs per ton; $\mathbf{C}_r$ is an $n \times 1$ vector of export prices per ton net of export costs; Ω is an $n \times n$ covariance matrix of crop revenues (prices times yield);[2] and k is a suitable average of individual farmers' risk-aversion parameters. This maximand is only applicable if $\mathbf{B}$ is symmetric (the integrability requirement). In the absence of estimates of cross-price

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[1] Integrability of product demand requires that the cross-price effects are equal over all commodity pairs. Relaxation of this assumption requires more difficult model solution procedures—such as linear complementarity programming (Takayama and Judge)—and the producer and consumer surplus measures used in this paper no longer would be applicable.

[2] We assume $\mathbf{C}_x$, $\mathbf{C}_r$ and $\mathbf{C}_m$ are not stochastic; hence the variance of income and total revenue are identical.

effects, the **B** matrix is specified as diagonal in the Guatemalan model.

As Hazell and Scandizzo (1974) have shown, the maximand (1) provides the market equilibria that would be arrived at if production is lagged and farmers act on the basis of price expectations that are formed independently of their expectations about yields. Such market equilibria are socially inefficient (Hazell and Scandizzo 1975). However, if producers act on the basis of revenue expectations, thereby taking account of any correlations between prices and yields, socially efficient market equilibria are attained. The maximand,

$$(2)\quad \text{Max } \theta = E[\mathbf{Q}'(\mathbf{A} - \tfrac{1}{2}\mathbf{BQ})] - \mathbf{C}'_x\mathbf{X} - \mathbf{C}'_r\mathbf{R} - \mathbf{C}'_m\mathbf{M} - k(\mathbf{X}'\Omega\mathbf{X})^{\frac{1}{2}} = \Phi - \tfrac{1}{2}\Sigma_i\Sigma_j X_i X_j \sigma_{ij} b_{ij},$$

where σ_{ij} denotes the covariance between the yields of the ith and jth crops, provides the socially preferred equilibrium solution (Hazell and Scandizzo 1977).

The covariance matrix of crop revenues is treated as a constant by Hazell and Scandizzo and is typically estimated on the basis of time-series data on prices and yields. While observed price and yield deviations around their mean (or trend lines) may be an acceptable measure of risk in market equilibrium, the revenue elements of Ω are not invariant with respect to their mean prices.[3] Thus, if the expected prices in the equilibrium solution are different from the sample mean prices used in the calculation of Ω, then Ω should be revised. Procedures for endogenizing the Ω matrix have not yet been developed; therefore, in the Guatemalan model, we used an iterative procedure. If, at the tth iteration the i, jth element of Ω had mean prices $\bar{P}_{it}$ and $\bar{P}_{jt}$, and these differed from the equilibrium prices $E(P_{it})$ and $E(P_{jt})$ obtained in the corresponding tth model solution, then $E(P_{it}) - \bar{P}_{it}$ and $E(P_{jt}) - \bar{P}_{jt}$ were added to the sample price observations for the ith and jth crops, ω_{ij} was recalculated, and a new solution was obtained. This procedure was repeated until $E(P_{it}) - \bar{P}_{it}$ and $E(P_{jt}) - \bar{P}_{jt}$ converged to approximately zero. In practice, Ω typically converged in three or four iterations.

Methodology of Price Stabilization Experiments

We are interested in a stabilization scheme in which the domestic price of beans is fixed at its expected market equilibrium value. Such price stabilization would be achieved through the establishment of buffer stocks. To assure a self-liquidating stock on average, the price at which a market is to be stabilized is the expected market clearing price in equilibrium. This price can be obtained from the model. The problem is to modify the model to obtain the market equilibrium solution corresponding to the stabilized situation.

The model solutions are conditioned in part by the covariance matrix Ω, and stabilizing the price of the jth crop changes the variance and the covariance terms involving that crop. An important part of the method of experimenting with price stabilization therefore follows: one must recalculate all the relevant elements of Ω using the stabilized price $\bar{P}_j = E(P_j)$ and then resolve the model for a new equilibrium.

However, producers will adjust their cropping patterns to arrive at a new optimal plan, given their assumed E, σ utility functions. This is the risk-response effect induced by stabilization, and the original expected market-clearing price for the stabilized crop no longer will be the same. The stabilized price, $\bar{P}_j = E(P_j)$, now will have to be revised to retain a self-liquidating buffer stock, the element of Ω recalculated, and the solution process repeated. This iterative procedure is repeated until Ω converges.

As will later become clear, a small modification is also required in the demand specification for the stabilized crop in equation (2). Q_{jt} is no longer stochastic when the stabilizing agency sells a fixed amount $\bar{Q}_j$ to consumers each year; and equation (2) must be revised so that $E(Q_j^2) = \bar{Q}_j^2$ for the stabilized commodity. This can be done by setting $\sigma_{ij} = 0$, all i, in equation (2).

The poststabilized solution provides the expected values of all activities in the new market equilibrium. Any changes from the prestabilized solution stem from supply adjustments following changes in farm-levels risk, or from the disappearance of the covariance between price and yield leading to identical revenue and price expectations for the stabilized crop. Assuming producers were risk-neutral ($k = 0$) and that they plan on the basis of price expectations (objective function [1]), then the pre- and poststabilized solutions would in fact be identical, with $\bar{P}_j$ remaining constant. Even though the model activity levels would not change under these conditions, the removal of price and market supply variations still leads to changes in the expected values of the consumers' surplus, producers' surplus, and income.

The surplus and income changes can be calculated in the model. Given our assumed market structure, prices in the tth year are given by $\mathbf{P}_t = \mathbf{A} - \mathbf{BQ}_t$. Expected consumers' surplus in the prestabilized situation is

$$(3)\quad E(W_c) = E[\mathbf{Q}'_t(\mathbf{A} - \tfrac{1}{2}\mathbf{BQ}_t) - \mathbf{P}'_t\mathbf{Q}_t], = \tfrac{1}{2}E(\mathbf{Q}'\mathbf{BQ}).$$

Expected producers' surplus is

$$(4)\quad E(W_p) = E[\mathbf{Q}'(\mathbf{A} - \mathbf{BQ})] - \mathbf{C}'_x\mathbf{X} + \mathbf{C}'_r\mathbf{R} - \mathbf{C}'_m\mathbf{M} - \mathrm{k}(\mathbf{X}'\Omega\mathbf{X})^{\frac{1}{2}},$$

where we have used an *ex post* measure of the surplus, that is, actual revenue less the *ex ante*

[3] Let $P^*_j = P_j + \lambda$ with λ constant, then $\text{Cov}(P^*_j n_j, P_i n_i) = \text{cov}(P_j n_j, P_i n_i) + \lambda \text{Cov}(n_j, P_i n_i)$.

costs of production incurred at the time when **X** is planted (Hazell and Scandizzo 1975).

The producer's surplus is defined net of the risk term $k(\mathbf{X}'\,\Omega\,\mathbf{X})^{\frac{1}{2}}$, which is the income compensation producers require for accepting the risks associated with **X**. By deleting this term in equation (4), the expected value of producers' income in the prestabilized markets is obtained.

To measure aggregate social welfare, we take a common approach and measure expected social welfare as the sum of the expected producers' and consumers' surplus. In the prestabilized market, this is the sum of equations (3) and (4) and is equal to model objective function (2). This welfare interpretation of (2) provides the rationale for the social efficiency of revenue expectations (Hazell and Scandizzo 1975, 1977).

The establishment of a buffer stock agency stabilizes the prices of a subset of the vector $\mathbf{P}_t$. By partioning the relevant matrices, the price and quantity vectors are

$$(5)\qquad \begin{pmatrix}\mathbf{P}_{1t}\\ \mathbf{P}_{2t}\end{pmatrix} = \begin{pmatrix}\mathbf{A}_1\\ \mathbf{A}_2\end{pmatrix}\begin{pmatrix}\mathbf{B}_{11} & \mathbf{B}_{12}\\ \mathbf{B}_{21} & \mathbf{B}_{22}\end{pmatrix}\begin{pmatrix}\mathbf{Q}_{1t}\\ \mathbf{Q}_{2t}\end{pmatrix}, \text{ and}$$

$$(6)\qquad \begin{pmatrix}\mathbf{Q}_{1t}\\ \mathbf{Q}_{2t}\end{pmatrix} = \begin{pmatrix}\mathbf{N}_{1t} & 0\\ 0 & \mathbf{N}_{2t}\end{pmatrix}\begin{pmatrix}\mathbf{X}_1\\ \mathbf{X}_2\end{pmatrix} + \begin{pmatrix}\mathbf{M}_1\\ \mathbf{M}_2\end{pmatrix} - \begin{pmatrix}\mathbf{R}_1\\ \mathbf{R}_2\end{pmatrix}.$$

If the buffer stock agency wishes to stabilize prices $\mathbf{P}_1$ at $\bar{\mathbf{P}}_1$, where $\bar{\mathbf{P}}_1$ is the vector of prices that ensure self-liquidating stocks on average, the agency would plan to buy all the production of $\mathbf{Q}_1$ each year and, by controlling imports $\mathbf{M}_1$ and exports $\mathbf{R}_1$, to release the quantities of $\mathbf{Q}_1$ to the domestic market each year that are required to maintain prices at $\bar{\mathbf{P}}_1$. If $\mathbf{Q}_1$ and $\mathbf{Q}_2$ are demand-independent groups (that is, $\mathbf{B}_{21} = \mathbf{B}_{12} = 0$), the agency trades constant amounts $\bar{\mathbf{M}}_1$ and $\bar{\mathbf{R}}_1$ each year and sells constant amounts $\bar{\mathbf{Q}}_1 = E(\mathbf{N}_1)\mathbf{X}_1 + \bar{\mathbf{M}}_1 - \bar{\mathbf{R}}_1$ to the domestic market.[4] When $\mathbf{Q}_1$ and $\mathbf{Q}_2$ are not demand independent, $\mathbf{P}_1$ is subject to random variations arising from $\mathbf{Q}_2$ as well as from variations in $\mathbf{Q}_1$. Since the agency would not carry stocks of $\mathbf{Q}_2$, the actual quantities of $\mathbf{Q}_1$ sold would have to be varied from year to year to compensate for variations in $\mathbf{Q}_2$. $\bar{\mathbf{Q}}_1$ would then denote only the expected value of the amounts sold by the agency to maintain prices at $\bar{\mathbf{P}}_1$.

Where $\bar{\mathbf{Q}}_1$, $\bar{\mathbf{M}}_1$ and $\bar{\mathbf{R}}_1$ are not stochastic, the expected consumers' and producers' surplus in the stabilized situation are

$$(7)\qquad E(W_c) = \tfrac{1}{2}\bar{\mathbf{Q}}'_1\mathbf{B}_{11}\bar{\mathbf{Q}}_1 + \tfrac{1}{2}E\,[\mathbf{Q}'_2\mathbf{B}_{22}\mathbf{Q}_2],$$

$$(8)\qquad E(W_p) = \bar{\mathbf{Q}}_1'\,(\mathbf{A}_1 - \mathbf{B}_{11}\bar{\mathbf{Q}}_1) + E\,[\mathbf{Q}'_2(\mathbf{A}_2 - \mathbf{B}_{22}\mathbf{Q}_2] - \mathbf{C}'_xX - \mathbf{C}'_m\mathbf{M} + \mathbf{C}'_r\mathbf{R} - k\,(\mathbf{X}'\mathbf{\Omega}\mathbf{X})^{\frac{1}{2}},$$

and expected producers' income is equation (8) with the risk term $k\,(\mathbf{X}'\mathbf{\Omega}\mathbf{X})^{\frac{1}{2}}$ omitted.

Taking the sum of equations (7) and (8), expected social welfare in the stabilized situation is

$$(9)\qquad E(W) = \bar{\mathbf{Q}}'_1\,(\mathbf{A}_1 - \tfrac{1}{2}\mathbf{B}_{11}\bar{\mathbf{Q}}_1) + E[\mathbf{Q}'_2(\mathbf{A}_2 - \tfrac{1}{2}\mathbf{B}_{22}\mathbf{Q}_2)] - \mathbf{C}'_x\mathbf{X} - \mathbf{C}'_m\mathbf{M} + \mathbf{C}'_r\mathbf{R} - k\,(\mathbf{X}'\mathbf{\Omega}\mathbf{X})^{\frac{1}{2}}.$$

Equation (9) is a modified version of (2) in which $E(Q_j^2)$ is replaced by $\bar{Q}_j^2$ for all stabilized commodities. It is also the relevant model maximand for obtaining the market equilibria corresponding to revenue-forecasting behavior in the stabilized situation. Because prices and yields are no longer correlated for the stabilized commodities, producers act as price forecasters when planning $\mathbf{X}_1$ and as revenue forecasters when planning $\mathbf{X}_2$.

The gain in expected social welfare from stabilizing $\mathbf{P}_1$ is the value of equation (9) minus equation (2). If producers are risk-neutral and plan on the basis of price forecasts, the values of **X**, **M**, and **R** remain constant; $\bar{\mathbf{Q}}_1$ equals $E\,(\mathbf{Q}_1)$ of the prestabilized situation; and the welfare gain is

$$(10)\qquad E(\Delta W) = \tfrac{1}{2}\,[E\,(\mathbf{Q}'_1\mathbf{B}_{11}\mathbf{Q}_1) - \bar{\mathbf{Q}}'_1\mathbf{B}_{11}\bar{\mathbf{Q}}_1] = \tfrac{1}{2}\,\Sigma_i\Sigma_j X_{1i}\,X_{1j}\sigma_{1ij}b_{1ij}.$$

To obtain the values of the surplus and income measures defined above, it is only necessary to incorporate equations (1), (2), and (4) into the model and to have access to the value of $k\,(\mathbf{X}'\mathbf{\Omega}\mathbf{X})^{\frac{1}{2}}$ from the solution. Since either (1) or (2) would be the model maximand, then only two additional accounting rows are required. These are quadratic equations, but they can be linearized concurrently with the objective function (Duloy and Norton).[5]

So far all the activity levels **X**, **M**, and **R** are treated as nonstochasic. Because **X** (the crop areas planted) depends in part on producers' forecasts about prices, it is implied that producers hold constant forecasts over time. In reality, forecasts about prices do change from year to year even when the markets are in equilibria and **X**, **R**, and **M** are stochastic.

If the assumption of nonstochastic activities is relaxed, the surplus and income measures used in the model will be incorrect. To derive the correct results, consider the generalized supply structure:

$$\mathbf{Q}_t = \mathbf{N}_t\mathbf{X}_t + \mathbf{M}_t - \mathbf{R}_t,$$

where t subscripts denote activities that are

[4] Complications arise when a stabilized commodity is traded at uncertain prices. The agency must then have the financial facilities to stabilize these prices for the domestic market. Fortunately this problem does not arise with beans in Guatemala because they are not traded.

[5] Linearization of (2) and (4) proved especially easy in the Guatemalan model because **B** is diagonal. In this case.

$$E\,[\mathbf{Q}'(\mathbf{A} - \tfrac{1}{2}\mathbf{B}\mathbf{Q})] = E(\mathbf{Q}')\,[\mathbf{A} - \tfrac{1}{2}\mathbf{B}\mathbf{M}E(\mathbf{Q})],$$

where **M** is a diagonal matrix with jth diagonal element $m_j = E(n_j^2)/E(n_j)^2 = 1 + R_j^2$, and R_j is the coefficient of variation of the yield of the jth crop. Since **M** is a constant, then **BM** can be calculated as part of the input to the model. The matrix **BM** remains diagonal, and the term $E(\mathbf{Q}')\,[\mathbf{A} - \tfrac{1}{2}\mathbf{B}\mathbf{M}\,E(\mathbf{Q})]$ can be linearized using the Duloy-Norton method. Note that m_j must be equated to unity for stabilization experiments on the jth crop.

stochastic over time. We also assume that trade is undertaken at uncertain prices.

Expected social welfare in period t in the pre-stabilized situation is now:

$$E(W) = E[\mathbf{Q}'(\mathbf{A} - \tfrac{1}{2}\mathbf{BQ})] - \mathbf{C}'_x E(\mathbf{X}) - E(\mathbf{C}'_m)E(\mathbf{M}) + E(\mathbf{C}'_r)E(\mathbf{R}) - kV(\mathbf{r}'\mathbf{X})^{\frac{1}{2}} + F,$$

where $F = \Sigma_j [\mathrm{cov}(C_{rj}, R_j) - \mathrm{cov}(C_{mj}, M_j)]$ and $V(\mathbf{r}'\mathbf{X})$ denotes the variance of total revenue. Now,

$$V(\mathbf{r}'\mathbf{X}) = V(\Sigma_j r_j X_j) = \Sigma_i \Sigma_j [E(X_i X_j r_i r_j) - E(X_i r_i)\, E(X_j r_j)],$$

which after some expansion yields

$$V(\mathbf{r}'\mathbf{X}) = E(\mathbf{X}')\Omega E(\mathbf{X}) + G,$$

where

$$G = \Sigma_i \Sigma_j [\mathrm{Cov}(X_i X_j, r_i r_j) + \mathrm{Cov}(X_i, X_j)E(r_i r_j) - \mathrm{cov}(X_i, r_i)E(X_j r_j) - E(X_i)E(r_i)\,\mathrm{cov}(X_j, r_j)].$$

Letting D denote $E(\mathbf{X}')\boldsymbol{\Omega}E(\mathbf{X})$, then a Taylor expansion of $V(\mathbf{r}'\mathbf{X})^{\frac{1}{2}} = (D + G)^{\frac{1}{2}}$ around D provides

$$V(\mathbf{r}'\mathbf{X})^{\frac{1}{2}} = D^{\frac{1}{2}} + \Sigma_s g_s(D)G^s,$$

where $g_1(D) = \frac{1}{2}D^{-\frac{1}{2}}$, $g_2(D) = -1/8D^{-3/2}$, and so forth.

Collecting terms, expected social welfare is

$$(11)\quad E(W) = \{E[\mathbf{Q}'(\mathbf{A} - \tfrac{1}{2}\mathbf{BQ})] - \mathbf{C}'_x E(\mathbf{X}) - E(\mathbf{C}'_m)E(\mathbf{M}) + E(\mathbf{C}'_r)E(\mathbf{R}) - k[E(\mathbf{X}')\boldsymbol{\Omega}E(\mathbf{X})]^{\frac{1}{2}}\} + F - k[\Sigma_s g_s(D)G^s].$$

The terms in the curled parentheses of (11) are equivalent to the value of $E(W)$ defined in (2), the only difference being that the activity levels are now defined as expected values. However, whereas (2) correctly measures expected social welfare when the activity levels are nonstochastic, it is now necessary to evaluate the additional terms F and $\Sigma_s g_s(D)G^s$. All the terms in F and G become zero if $\mathbf{X}$, $\mathbf{R}$, and $\mathbf{M}$ are nonstochastic; therefore, their omission from (2) is justified.

$\mathbf{X}$ is stochastic because producers adjust their cropping patterns each year according to changes in their forecasts about prices. When the price vector $\mathbf{P}_1$ is stabilized at $\bar{\mathbf{P}}_1$, $\mathbf{X}_1$ becomes nonstochastic. The buffer stock agency also takes control of all importing and exporting activities for $\mathbf{Q}_1$, and $\mathbf{M}_1$ and $\mathbf{R}_1$ are stabilized at $\bar{\mathbf{M}}_1$ and $\bar{\mathbf{R}}_1$. As such, all covariance terms in F and G associated with activities in the vectors $\mathbf{X}_1$, $\mathbf{M}_1$, and $\mathbf{R}_1$ become zero with stabilization, and the expected value of social welfare in the stabilized situation is equation (9) $+ F - k\,\Sigma_s g_s(D)G^s$, where F and D contain only the relevant covariances.

Estimates of the gain in social welfare from price stabilization based on equations (2) and (9) could be misleading if changes in F and $\Sigma_s g_s(D)G^s$ are large. There is no basis for calculating these terms in a mathematical programming model, but some indication of their value can be obtained from time-series data.

A similar analysis of the expected producers' surplus leads to a generalized form of (4) in which the terms $F - k\,\Sigma_s g_s(D)G^s$ are added. The consumers' surplus is not affected.

The Guatemalan Experiments

Table 1 contains some basic foodcrop results obtained from the model, together with actual data for 1976, the year for which the model was numerically specified.[6] The results are presented for price-and revenue-forecasting behavior (using model maximands (1) and (2), respectively) and for three different levels of risk aversion. A k value of zero implies risk neutrality; k values of 1.65 and 3.16 represent "reasonable" and "extreme" levels of risk aversion, respectively. Specifically, k values of 1.65 and 3.16 correspond to producers' maximizing the 0.05 and 0.001 percentiles of their income distributions, providing these are normally distributed (Baumol).[7]

The results in table 1 suggest that the model describes 1976 production levels quite well. They are

[6] The model also includes coffee, sugar, cotton, and domestic and export bananas, but the production of these crops was insensitive to the experiments reported here.

[7] On the basis of a chi-square test of detrended time-series data, it was not possible to reject the null hypothesis that incomes were normally distributed.

Table 1. Results for Various Levels of Risk Aversion and Alternative Expectations Behavior

	Price Expectations			Revenue Expectations			1976
	$k = 0$	$k = 1.65$	$k = 3.16$	$k = 0$	$k = 1.66$	$k = 3.15$	Actuals
Production							
(10^3 metric tons)							
Maize	1,076.5	1,031.6	1,031.6	1,076.5	1,031.6	986.8	1,005.7
Rice	27.9	27.9	29.0	26.7	26.7	26.7	34.1
Sorghum	52.3	50.2	48.1	50.2	48.2	46.0	49.2
Beans	98.1	90.2	41.2	93.5	86.3	41.2	92.1
Wheat	67.1	67.1	67.1	67.1	67.1	67.1	56.9
Social Welfare[a]							
(Millions $US)	1,067.0	980.9	898.0	1,071.9	981.6	898.7	

[a] Uncorrected for stochastic activity levels.

Table 2. Results for Various Price Stabilization Experiments

	$k = 1.65$		$k = 3.16$		$k = 1.65$	
	Prestabilized Price Model	% Change with Bean Price Stabilized	Prestabilized Price Model	% Change with Bean Price Stabilized	Prestabilized Revenue Model	% Change with Bean Price Stabilized
Income and welfare measures (millions $US)						
A. Uncorrected measures						
Social welfare	980.9	1.30	898.0	1.65	981.6	1.22
Consumers' surplus	906.3	0.02	896.9	−2.80	891.6	0.87
Producers' income	275.3	2.36	263.2	17.10	288.9	−0.12
Standard deviation of producers' income[a]	53.7	−7.60	49.4	1.77	53.1	−6.54
B. Corrected measures[b]						
Social Welfare	990.8	0.39	908.3	−0.26	991.5	0.12
Producers' income	285.6	2.32	272.5	16.55	298.2	−0.07
Agricultural trade balance (millions $US)	281.1	0	260.3	7.88	282.2	0
Agricultural employment (Thousands full-time jobs)	5083.0	0.33	4946.8	1.34	5059.5	0.65
Production (Thousands metric tons)						
Maize	1031.6	0	1031.6	−4.34	1031.6	0
Rice	27.9	0	29.0	−3.79	26.7	0
Sorghum	50.2	0	48.1	0	48.2	0
Beans	90.2	4.32	41.2	118.93	86.3	9.04
Wheat	67.1	0	67.1	0	67.1	0
Retail prices ($US/Metric Ton)						
Maize	179	0	179	14.53	179	0
Rice flour	322	0	258	24.81	387	0
Sorghum	171	0	199	0	199	0
Beans	516	−14.15	590	−12.54	590	−24.92
Wheat flour	510	0	510	0	510	0

[a] Sum of standard deviations over all farm groups.
[b] Corrected for stochastic activity levels.

consistent with an assumption of "reasonable" risk behavior ($k = 1.65$). The results obtained for price and revenue expectations are similar for given values of k. As risk aversion increases, bean production is significantly curtailed. Beans are clearly a high-risk crop and a suitable candidate for illustrative price stabilization experiments.

Price stabilization cannot affect the model's activity levels if producers are risk neutral and plan on the basis of price expectations, but it does lead to a small gain in uncorrected social welfare of about $5 million. The more interesting results for k values of 1.65 and 3.16 are summarized in table 2. Surplus measures are reported as obtained from the model and after correcting for stochastic variation in activity levels, as measured from time-series data.

Price stabilization for beans leads to an uncorrected gain in social welfare of about $12 million when $k = 1.65$. When corrected for observed variations in X over time, the gain is much smaller; it is $4 million and $1.2 million, respectively, for price and revenue expectations behavior. The uncorrected gain is almost $15 million when $k = 3.16$, but it is essentially zero when the necessary corrections are made. If our calculations are correct, producers in Guatemala appear to be adjusting their cropping patterns each year in a manner that is socially efficient. Stabilizing the bean price would do little to improve their efficiency.

There are other effects from stabilizing bean prices. When $k = 1.65$, bean production increases by 4.3% and 9% for price and revenue expectations, respectively. This additional output is produced with resources that otherwise would be idle.[8] There is also a sizeable decline in the standard deviation of producers' income. In both cases, the domestic price declines substantially, and there is an increase in agricultural employment, of 17,000 jobs in the case of price expectations, and of 33,000 jobs with revenue expectations. The gains are more exaggerated under extreme risk aversion, and bean production more than doubles. However, because beans are imported in the prestabilized solution for this value of k, the extra production largely substitutes for imports. This leads to a decline in the domestic price of only 13%. The agricultural trade balance is affected favorably, and the large increase in bean production leads to a decrease in maize and rice production and an increase in the standard deviation of producers' income.

The results in table 2 show some ambiguity in the gain to producers and consumers. Consumers gain from bean price stabilization when $k = 1.65$, but lose when $k = 3.16$. Average producers' income increases when they hold price expectations (by 2.3% and 17% for k values of 1.65 and 3.16, respectively) but declines when they plan on the basis of revenue expectations.

[8] Production is modelled by three different farm sizes representing primarily subsistance farms, market-oriented farms which rely predominantly on family labor, and large commercial farms which use hired labor and produce most of the traditional export crops. The middle-sized farms have some idle land and labor resources in the model solution (which accords well with available evidence), and these resources are utilized more fully in the model when bean prices are stabilized.

Conclusions

Price-endogenous mathematical programming models are proposed in this paper as useful tools for analyzing price stabilization policies. Their particular attractions for this purpose are that they (a) take explicit account of interactions between commodities in supply and demand, (b) can incorporate risk-averse behavior and simulate the supply response effects of stabilization policies, (c) can produce much information about wider impacts of price stabilization, and (d) are relatively easy to solve, especially when linearized.

The main limitation of the approach is that it cannot be used to derive storage costs or to analyze effects of various stock sizes. Although the analysis proposed here assumes that prices are stabilized at a single value, the method does provide a useful technique for a first round of analysis which might be supplemented later with other simulation techniques.

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Foreign Competition and Trade Policy for the Florida Lime Industry

Emilio Pagoulatos, J. Scott Shonkwiler, and Robert L. Degner

The Florida fresh lime industry recently has faced increasing competition from imports, particularly from Mexico. Concern about increased lime imports began in the mid-1970s and has focused on their potentially adverse effect on Florida prices and production. In order to evaluate the potential threat of foreign competition on Florida's lime industry and the trade policy alternatives, quantitative estimates are needed of the impact of imports on the industry.

The purpose of this paper is to estimate the effects of import competition and alternative trade policies on the Florida lime industry (Andrew, DeBoon, McPherson; Freebairn and Rausser; Novakovic and Thompson; Salathe, Dobson, Peterson). The methodology involves specifying and estimating an econometric model of the Florida lime and U.S. trade sectors. A set of reduced-form equations is derived from the simultaneous equation model. The estimated multipliers are used to measure the impacts of alternative U.S. tariff and quota policies on lime imports, Florida lime production, and prices.

Florida's Fresh Lime Industry

Florida and California are the only two states in the United States producing limes commercially (Degner and Rooks; Degner, Shonkwiler, Cubenas.) Since the early 1970s, Florida has accounted for about 90% of the domestic lime acreage and California the remaining 10%.

Imports have increased steadily since 1972–73, when they constituted only 4% of U.S. fresh lime supply. By 1976–77, however, imports accounted for about 15%. In the 1977–78 season, imports represented approximately one-third of U.S. fresh lime supplies, and in the 1979–80 season, over 37%. Fresh limes are protected in the United States by a specific tariff (TSUS item no. 147.22) of one cent per pound. In recent years the ad volorem equivalent of this tariff has been about 7%.

Although a number of Caribbean countries export fresh limes to the United States, Mexico is the dominant source. Mexico has almost 112,000 acres of limes, compared with Florida's 4,600. Although a high proportion of Mexico's acreage is the seeded Mexican lime used for essential oil production, production of Persian limes, the preferred fresh market variety grown by Florida producers, is increasing.

The Economic Model

The main components of the model are the foreign trade sector and the Florida market for limes. This allows the simultaneous determination of import and export prices, import levels, and the quantity and price of Florida limes.

Following Magee and Goldstein and Khan, we specify the foreign trade sector to include the supply of lime exports from Mexico (M^s), the U.S. demand for lime imports (M^d), and the relative price equation to link the U.S. import price (PM) with the Mexican export price (PX).

In the absence of export tariffs, we specify the export supply of limes from Mexico as a function of the export price (in pesos), real income in Mexico ($YMEX$), and the lagged export price:

$$(1) \qquad M_t^s = f(PX_t, YMEX_t, PX_{t-1}).$$

Current and lagged export prices are expected to be positively related to exports. As export prices rise, production for export becomes more profitable, and allocation to the export market increases. However, as income rises in the exporting country, domestic demand for the product rises, and *ceteris paribus*, exports decline.

The import demand for limes is specified as follows:

$$(2) \qquad M_t^d = g(PM_t, QF_t, YUS_t, CPI_t),$$

where PM is the import price (in dollars), QF is the quantity of limes marketed by Florida producers, YUS is the U.S. income level, and CPI is the U.S. consumer price index (Leamer and Stern, pp. 8–17). It is hypothesized that the U.S. demand for imported limes is negatively related to import price and positively related to consumer income. In addition, Florida marketings should exert a negative influence on imports. Equation (2) also reflects the hypothesis that as the price of all other consumer goods (CPI) rises, *ceteris paribus*, the import demand increases.

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Finally, the following identities complete the specification of the foreign trade sector:

$$PM_t = \frac{1}{r_t} PX_t + T, \quad \text{and} \tag{3}$$

$$M_t^s = M_t^d. \tag{4}$$

Expression (3) relates the dollar-valued import price (PM) to the peso-valued export price received by Mexican suppliers. This identity explicitly introduces the foreign exchange rate (r = pesos/dollar) and the U.S. specific tariff rate (T = \$.01/lb.). Expression (4) imposes a market-clearing solution on the trade side of the model.

With regard to the domestic side of the model, the specification of the Florida lime supply function is

$$QF_t^s = h\Big(\sum_{i=1}^{k} PF_{t-i}, \sum_{i=1}^{m} PPF_{t-i}, FW_t, QF_{t-1}, TIME\Big), \tag{5}$$

where PF is the Florida lime price, PPF represents prices paid by growers for the purchase of production inputs, FW is a variable denoting Florida weather conditions, and $TIME$ is an annual trend term. Given the perennial nature of limes, no attempt was made to include alternative crop prices in the supply equation.

The lags on product and input prices account for the influence of expected prices and costs on supply due to the time lapse between planting and output. French and Matthews recognize that, for perennial crops, "producers might consider experience over several years as a better indicator of expected profitability" (p. 484). Lime prices should exert a positive impact on supply, while prices paid by farmers should negatively affect supply. Lagged lime output was included in the specification to capture partial production adjustments, and it is expected that $0 < \partial h/\partial QF_{t-1} < 1$. Finally, the time trend represents the effects of omitted variables, such as technological change, that have exerted systematic effects over time.

The quantity of Florida limes demanded is postulated to depend upon their price (PF), the U.S. income level (YUS), the overall price level (CPI), and current and lagged imports (M):

$$QF_t^d = i(PF_t, YUS_t, CPI_t, M_t, M_{t-1}). \tag{6}$$

Own-price and consumer income are expected to enter the equation with negative and positive signs, respectively. Prices of all other commodities (CPI) should be negatively related to demand. In addition, the quantity of limes demanded depends as well on the availability of imported limes. Increased quantities of the imports should erode demand for the domestic product. The sustained increase in lime imports, evidence that foreign competitors are gaining market share, should negatively influence the demand for Florida limes.[1]

To complete the specification of the Florida lime market, we require that

$$QF_t^s = QF_t^d, \tag{7}$$

assuring a market-clearing equilibrium.

The Estimated Model

This economic model consists of four behavioral equations and three identities. The parameters of the behavioral equations were estimated simultaneously via three-stage least squares (3SLS) using annual observations for the period 1957 through 197[illegible]. The estimated equations are reported in table 1, along with their corresponding structural R_c^2's and the variable definitions.[2]

All four equations exhibit good structural fits, as evidenced by the high R_c^2's and the overall significance of the estimated parameters. Parameter signs conform to theoretical expectations. All variables enter the import supply equation with their expected signs at high levels of significance. In the import demand equation, the variable PM exhibits the expected sign but is only marginally significant. The income measure, YUS, also has the postulated sign but is not significant, perhaps due to its high degree of correlation with CPI. Finally, Florida lime production was the strongest explanatory variable in the import demand equation.

In the Florida supply equation, polynomial distributed lags were imposed on the price and cost series. Prices were assumed to follow a four-period, first-order, polynomial distributed lag, whereas production costs were allowed to follow a four-period, second-order distributed lag.[3] In both cases all parameters are of expected sign and highly significant, except for that on PPF_{t-1}. The large coefficient on QF_{t-1} reflects the substantial inertia which dominates the supply side of the Florida market. Finally, the Durbin m-statistic provides an appropriate test for residual autocorrelation because of the presence of a lagged dependent variable (Spencer).

The estimated Florida demand equation also conforms closely to the hypotheses. The price of Florida limes and domestic income influence the

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[1] Ward and De found that lemons are not a significant competing crop with Florida limes. No attempt therefore was made to include lemon supplies in the Florida lime demand equation.

[2] The R_c^2 measure presented relates to a single structural equation before the third stage estimation takes place. It has been shown to be equivalent to the R^2 for a reduced-form equation when estimated by the partially restricted reduced-form estimation method (Knight).

[3] The calculated F-statistic for discriminating between the unconstrained lag model and the reported model was $F_{3,10} = .120$, indicating that the imposed lag forms do not contradict the sample data. A first-order polynomial distributed lag was investigated for the cost series, but a specification error test suggested by Harper rejects the polynomial degree at the .01 level.

Table 1. 3SLS Structural Equation Estimates of Model for Limes

Estimated Equations		R_c^{2a}
Import supply M_t^s	$= -20.13 + 38.73\,PX_t - 15.04\,YMEX_t + 71.89\,PX_{t-1}$ (10.31)[b] (15.67) (4.64) (17.17)	.903
Import demand M_t^d	$= -86.67 - 4.26\,PM_t - .126\,QF_t + .0018\,YUS_t + 2.65\,CPI_t$ (44.27) (3.34) (.022) (.0081) (1.17)	.941
Florida supply QF_t^s	$= 1{,}044.3 - 58.13\,PV_{t-1} + 43.61\,PF_{t-2} + 29.07\,PF_{t-3}$ (172.49) (11.43) (8.57) (5.72) $+ 14.54\,PF_{t-4} + 2.55\,PPF_{t-1} - 6.95\,PPF_{t-2} - 10.54\,PPF_{t-3}$ (2.86) (2.36) (1.12) (2.32) $- 8.23\,PPF_{t-4} - 80.38\,FW_t + .862\,QF_{t-1} - 28.12\,TIME_t^c$ (1.99) (25.68) (.152) (7.05)	.940
Florida demand QF_t^d	$= 224.12 - 40.90\,PF_t + .156\,YUS_t - 2.21\,CPI_t - 1.09\,M_t$ (157.69) (10.16) (.029) (3.50) (.712) $- 2.13M_{t-1}$ (.340)	.971

Sources: Data were obtained from standard USDA, IMF, and other governmental publications.

Note: Endogenous variables: M_t is U.S. imports of limes at year t (m. lbs.); PX_t, Mexican lime export price (pesos/lb.); PM_t, U.S. lime import price ($/lb.); QF_t, Florida lime production (m. lbs.); PF_t, Florida wholesale lime price (¢/lb.). Exogenous variables: *YMEX* is real Mexican gross domestic product (deflated by Mexican wholesale price index; billion pesos); *YUS*, U.S. disposable personal income (billion dollars); *CPI*, U.S. consumer nondurable goods price index (1972 = 100); PPF_t, U.S. index of prices paid by farmers (1967 = 100); *FW*, Florida weather dummy variable (*FW* = 1 for years with unfavorable weather conditions, freezes or hurricanes; and *FW* = 0 in remaining years); *TIME*, annual trend term, 1957–58 season is year 1.

[a] This is the Carter-Nager measure of correlation as discussed by Knight for all equations except the Florida supply equation, where the OLS R^2 is reported.

[b] Asymptotic standard errors in parentheses.

[c] The hypothesis of no first-order autocorrelation of the OLS estimate of this equation could not be rejected at the .1 level using Durbin's alternative test as suggested by Spencer.

demand to a considerable extent. The estimated price and income elasticities of demand are −.0.64 and +2.00, respectively. In this equation, *CPI* has the proper sign but is not statistically significant, due perhaps to its high correlation with *YUS*. Current imports are only marginally significant. Lagged imports, however, appear to have a significant effect. This supports the hypothesis that sustained increases in imports have an adverse effect on the demand for Florida limes.

Model Validation

The reduced-form equations were derived and the endogenous variables were simulated over the sample period in order to evaluate the model's forecasting performance. Both static and dynamic simulations were performed using the estimated or base model. Unlike the static simulation which uses actual values for lagged endogenous variables, the dynamic simulation employs, instead, their previously solved values.

In order to assess the model's ability to track history, the squared correlations between actual and simulated values of the endogenous variables were calculated. The following results were obtained:

Simulation	Endogenous Variable				
	M	*PM*	*PX*	*FQ*	*PF*
Static	.94	.72	.93	.94	.96
Dynamic	.95	.76	.92	.89	.86

The reduced-form solution of the model under the two simulation strategies appears acceptable for all variables except the U.S. import price (*PM*). Because this variable has little impact on lime imports (*M*) in the structural model, imports are simulated quite accurately.

Trade Policy Simulations

Imports, Florida output, and Florida prices were simulated over the 1970–78 period under the current U.S. tariff policy (base value). Next, four alternative tariff and quota policies were incorporated into the model, and simulation results for the 1970–78 period were compared to the base solution values. The hypothetical trade policies considered are (*a*) a no tariff or free-trade policy, involving the elimination of the 1¢ per pound specific tariff on limes, (*b*) doubling of the current tariff to 2¢ per pound, (*c*) a further increase in the tariff to 5¢ per pound, and (*d*) the imposition of a fixed impor

Table 2. Simulated Values for Lime Imports, Florida Production, and Price under Alternative Trade Policies, 1970–78

Exogenous Variable	Trade Policy	Year 1970	1971	1972	1973	1974	1975	1976	1977	1978	Mean 1970–78	Change from Base Value (%)
Lime imports (million lbs.)	Base value (actual tariff)	3.35	4.47	4.03	7.18	7.27	8.99	15.3	21.2	20.5	10.25	
	No tariff	3.76	4.99	4.42	7.69	7.67	9.50	15.8	22.0	21.2	10.78	+5.2
	Tariff = 2¢/lb.	2.95	3.94	3.64	6.67	6.86	8.47	14.7	20.4	19.8	9.71	−5.3
	Tariff = 5¢/lb.	1.75	2.37	2.46	5.13	5.64	6.93	13.1	17.9	17.7	8.11	−20.9
Florida lime production (million lbs.)	Base value (actual tariff)	73.7	77.9	76.8	69.3	99.8	96.8	68.6	43.1	59.6	73.8	
	No tariff	72.2	76.4	75.5	67.9	98.4	95.3	67.2	40.5	57.3	72.3	−2.0
	Tariff = 2¢/lb.	75.1	79.4	78.1	70.7	101.2	98.3	70.0	43.7	61.9	75.4	+2.2
	Tariff = 5¢/lb.	79.6	83.8	82.0	72.0	105.5	102.7	74.0	48.6	68.9	79.7	+8.0
	Import quota ((M ≤ mill. lbs.)	73.8	78.4	79.7	73.7	102.0	104.6	81.7	67.4	113.3	85.7	+16.1
Florida lime price /¢/lb.)	Base value (actual tariff)	4.79	6.51	8.36	13.00	6.14	9.74	17.50	23.40	21.50	12.30	
4.79	6.51	4.77	6.52	8.30	13.00	6.11	9.75	17.40	23.30	21.50	12.30	0.0
	No tariff	4.81	6.50	8.41	12.90	6.16	9.72	17.60	23.50	21.60	12.40	+0.8
	Tariff = 2¢/lb.	4.87	6.46	8.59	12.90	6.24	9.68	17.80	23.80	21.70	12.40	+0.8
	Tariff = 5¢/lb.	5.12	6.70	8.17	12.80	7.32	10.10	19.10	26.90	21.40	13.10	+6.5
	Import quota (M ≤ mill. lbs.)											

quota of 5 million pounds per year.[4] Table 2 shows the values of imports, Florida output, and prices over the simulation period.

The free-trade alternative implies an average increase in lime imports of 5.2% over the simulation period. Under the same policy, Florida production declines by an average of 2% per year, with no appreciable effect on Florida prices.

Doubling the existing specific tariff results in a moderate (2.2%) increase in Florida's output and a more substantial decline of yearly imports. Florida prices exhibit a negligible increase of .08% per year. The further increase of the tariff to 5¢ per pound results in a similar pattern. In this case, both the simulation of Florida's production and the discouragement of imports is more pronounced than under the previous alternative. Again, no appreciable effect is found on Florida prices, indicating a noninflationary impact for specific tariff increases on fresh limes.

Finally, imposing a fixed import quota of 5 million pounds per year implies a decline of over 50% in total imports during the 1977–78 period. This would have increased Florida output an average of 16.1% per year and Florida prices an average of 6.5% annually, suggesting a mean tariff equivalent of this quota of 9.8¢ per pound. This latter alternative is undoubtedly inflationary. Apparently, only increases in the U.S. specific tariff could benefit Florida growers without at the same time increasing the cost borne by U.S. consumers.

Conclusions

This estimated model shows that increased import competition, particulary from Mexico, had an adverse effect on Florida's market. Simulation of the model under alternatve U.S. trade policies yields some interesting results. The free-trade alternative would increase imports and reduce Florida's output without affecting Florida prices. Increases in the U.S. specific tariff level would decrease imports and stimulate production in Florida but would have only a limited upward impact on prices. Limiting imports to pre-1973 levels, via the imposition of a fixed import quota, would provide a considerable stimulus for increasing Florida's output and at the same time raise Florida prices.

These results clearly are positive rather than normative. U.S. trade policy for limes, as well as for other products, should not be established solely on the basis of benefits to specific producer groups, but on wider consideration of both producers and consumers.

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[4] To examine the implications of a hypothetical fixed import quota the foreign trade sector was exogenized. The import quota of 5 million lbs./year was chosen to represent the approximate level of imports prior to the intensification of import competition in 1973.

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Induced Innovations and Farm Mechanization

Yoav Kislev and Willis Peterson

There are two traditional explanations to the revolutionary machine-labor substitution in American agriculture. One is that technical change in agriculture caused machines to be introduced and labor to become unwanted. The alternative explanation is that, from the farm sector point of view, labor's exit is primarily a market phenomenon guided by rising urban opportunities and declining real machinery costs.

If mechanization and labor exit are due to technical change in agriculture, then they come mainly from the public agent of farm technology—the agricultural research system; the research system should be held responsible for the social consequences of farm mechanization, and it should be budgeted and directed accordingly. On the other hand, if mechanization and exit from farming are caused mostly by external price and wage changes, the responsibility of the research system is limited principally to technology improvement.

In this note we discuss the newly emerging tradition of induced innovation and its relation to the alternative explanations of machine-labor substitution in agriculture. We first clarify the conceptual basis of the induced innovation hypothesis and the related innovation possibility function. Second, we call into question the validity of some of the empirical applications. We argue that an incomplete conceptualization of the induced innovation idea has led to invalid empirical tests and to inappropriate implications on the causes of American farm mechanization.

The Hicksian Framework

It is useful to view the process of price-induced technical change as if it occurs in two stages. In figure 1 the initial isoproduct curve, I_1, and price ratio, P_1, result in an equilibrium, cost-minimizing combination of capital and labor at point A. As prices change to P_2, the new equilibrium point along I_1 is B. According to the induced innovation hypothesis, this change in relative prices causes an asymmetric shift in the production function. This is represented in the diagram by the shift in the isoquant from I_1 to I_2. Now the equilibrium point is at C for the price ratio P_2. The capital-labor ratio is increased in two stages: from A to B in response to the price change and from B to C in response to induced technical change.

Technological change is a function of the available stock of knowledge and the resources devoted to research and development. The concept of the innovation possibility function (the meta-production function in the terminology of Hayami and Ruttan) was introduced to formalize these relations. Hicks originally assumed innovation possibilities to be basically neutral; subsequent literature relaxed this assumption (Kennedy). If it is comparatively easier to develop technology that will save relatively more of a single factor, labor for example, one could say that the innovation possibility function is biased in a labor-saving or capital-using direction.

Biasedness need not be associated with price changes. In terms of the diagram, if technological changes took place and the innovation possibility function is biased in a labor-saving direction, then I_1 could shift to I_2 and equilibrium; still with the price ratio P_1, will move from A to D, increasing the capital-labor ratio.

Agriculture and Manufacturing

Much of the new technology that has affected productivity in agriculture was developed in the manufacturing sector and introduced into the farm sector, embodied in new or improved inputs—mechanical and chemical. The aggregate, economywide framework of the induced innovation hypothesis does not account for the intersectoral transfer of technology because the whole economy is taken as one sector. However, when applying the induced innovation idea to a single sector such as agriculture, it may be necessary to separate the sector where the technology is developed from the sector where it is used. Otherwise market phenomena reflecting farmers' responses to relative factor price changes may be mistakenly identified as technical change internal to agriculture.

Commonly, the output of certain manufacturing industries, such as machinery, commercial fertilizer, and other farm supplies, are counted as inputs to the farm sector in productivity studies. Alternatively, however, manufacturing and agriculture could be combined into a single sector. If combined, factors purchased by farmers from the farm

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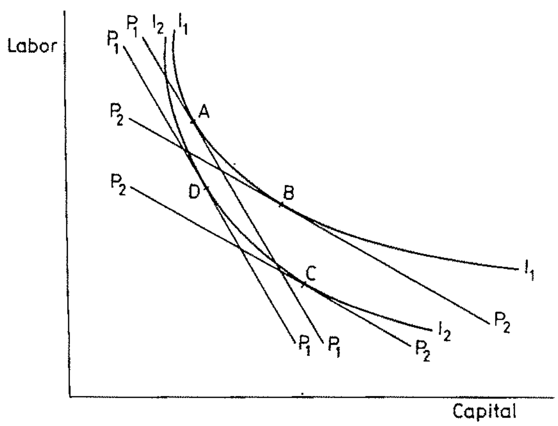

Figure 1. Induced technical change

supply industries will be regarded as intermediate goods, and the extrasectoral inputs will be such things as energy, steel, and raw materials, plus total capital and labor in the combined sector. In fact, the induced innovation hypothesis for agriculture originally was formulated (though not estimated) in the framework of a combined agriculture-manufacturing sector; at least this is how we read the theoretical sections of chapters 4 and 5 of Hayami and Ruttan.

In other cases, particularly if the empirical analysis is limited to agriculture, it is necessary to recognize explicitly that farming and manufacturing are two separate sectors. The induced innovation hypothesis as applied to agriculture should then be interpreted as the assertion that relative price changes induce innovations through two separate channels—external and internal. Innovations in manufacturing represent external technical change to agriculture which may or may not show up in the conventional estimates as productivity gains in the latter sector. If the new technology takes the form of product innovations, and if measures of the new or improved inputs (machines, let us say) do not accurately reflect quality changes, there may be a shift in the estimated agricultural production function as in figure 1. If it is a process innovation, such as the ability to produce nitrogen fertilizer at a lower cost, it may show up as a change in relative prices represented by a movement along an isoquant or production function. Better products often carry higher price tags, but farmers will not purchase the new or improved inputs unless their quality-adjusted prices are lower than the old input prices. Product innovations create, therefore, an identification problem. If these inputs are not adjusted for quality, farmers will be seen as increasing demand—buying more at higher prices. On the other hand, if these inputs are adjusted for quality, farmers will be seen as reacting to shifts in the supply of machine services—buying more at lower prices. In the latter case, there will be no measured technical change in agriculture; all of it will be seen to occur in manufacturing.

It is inconsistent to leave new or improved inputs created by product innovations in manufacturing unadjusted for quality, calling this technical change in agriculture, while treating process innovations which result in lower-priced inputs as a market phenomenon. As far as agriculture is concerned, both types of innovations are the same. Both result in lower effective prices of purchased inputs to farmers. Purchased inputs should therefore be adjusted for quality.[1]

Technical change also may occur in the agricultural sector, particularly if one defines this sector as including the research and development arm of farmers, namely, agricultural experiment stations. One might refer to the production of new varieties of crops, improved breeds of livestock, or new knowledge utilized directly by farmers as internal technical change, Machine-biased internal technical change might occur, for example, if new varieties of crops are adopted which require more mechanical services to insure proper timing of planting or harvest. In this case, farmers actually will increase their demand for machines and buy more of them even at higher real prices. Here, as elsewhere, one would not find productivity growth in agriculture if agricultural inputs were perfectly adjusted for quality. However, there would still be an increase in demand for machinery.

Empirical Application

Hayami and Ruttan did not explicitly separate internal and external technical change in their application of the concept of the induced innovation to agriculture. They were interested in international comparisons, particularly in demonstrating how agriculture of the comparatively capital-rich countries moved in the direction of labor-saving technology and how other countries, such as Japan, constrained by low land-labor ratios, developed and adopted land-augmenting innovations. For this analysis, the single-sector framework was a useful conceptualization and it was not crucial to distinguish between innovations in agriculture and innovations created in manufacturing. (Hayami and Ruttan did, however, discuss at length the mechanism of the transmission of the economic signals from commercial agriculture to the public agricultural research system.)

A detailed application of the induced innovation hypothesis to U.S. agriculture has been carried out by Binswanger for the 1912–68 period. His approach involved a two-stage estimation of the

[1] Quality unadjusted inputs are not only inconsistent in the analysis of technical change; they are simply meaningless. Inputs always should be measured in standard efficiency units. A simple addition of different quality tractors, for example, is as meaningless as adding apples and oranges.

biasedness of technical change in agriculture. First, elasticities of substitution in a five-input model of the farm sector were estimated. The second stage was an attempt to separate substitution of factors along isoquants in response to price changes from substitution due to biased technical change—shifts of the isoquants.

The real price of machinery in Binswanger's study is reported in table 1 (our data are discussed below). In his multifactor analysis, Binswanger employed the ratio of the price of machinery to the aggregate price of all inputs in agriculture. To focus on the machine-labor relation, we calculated from his data the implied ratio of machine price to the wage rate. In general, both ratios exhibit similar trends. The real machine price was comparatively high in the decade of the 1930s, mainly because of the decline in farm wage rates. In both series the real price of machines was higher after World War II than in the 1920s. The series differ in one respect: relative to all inputs, machinery prices are reported to increase substantially after the war; while relative to labor, machinery prices are comparatively stable for this period.

Whether the original five-factor perspective is adopted or the narrower two-input, labor and machinery point-of-view is taken, the data presented in part A of table 1 indicate that machine-labor substitution after World War II could not be a market phenomenon, i.e., it could not be a process of substitution in response to relative factor price changes. Indeed, Binswanger (p. 223) reports "that overall technical change was machinery-using, despite a substantial overall rise in the relative machinery price." These findings imply that internal farm sector technical changes which shifted the demand for machinery were the sole reason for the vast substitution of machinery for labor after World War II.

Table 1: Indices of Real Price of Machinery

	Ratio to			Ratio to	
Year	All inputs	Labor	Year	All inputs	Labor
A. Binswanger					
1912	100	100	1944	121	112
1916	102	103	1948	106	91
1920	84	78	1952	131	110
1924	93	83	1956	140	104
1928	98	83	1960	155	109
1932	141	119	1964	160	107
1936	162	167	1968	154	96
1940	164	161			
B. Custom rates					
1930	100				
1950	56				
1970	35				

Sources: Binswanger, table 7-1; custom rates, Kislev and Peterson, table 3.
Note: Binswanger's data are ratios of machine prices to prices of "all inputs" or "labor." Custom rates are ratios of rates in combine harvesting to agricultural wage rates.

Internal technical changes could have occurred because of learning by doing or the introduction of new crop varieties and other inputs. However, from what we know about U.S. agriculture, it is hard to believe that farm mechanization after World War II should all be attributed to new varieties and similar on-the-farm factors. The development of the machine-adapted tomato varieties, for example, began in 1943, when the shortage of labor was strongly felt (Rasmussen). It is hard to think of other major clear-cut cases. Some of the new chemicals require new machines to apply but at the same time save on machines by reducing tillage work.

The main empirical difficulty we see with Binswanger's analysis is his failure to adjust machinery prices for quality changes. The official U.S. Department of Agriculture (USDA) machinery price index, which he used, has been shown to overstate the increase in machinery prices because quality changes are not accounted for (Griliches, Fettig). The USDA series also overlooks the substantial decrease in the effective cost of mechanical services caused by the increasing importance of income taxes, particularly the accelerated depreciation and investment credit provisions of the tax law. In an attempt to avoid these misspecifications, we collected data on custom rates in combine harvesting. These rates reflect the market evaluation of quality changes and other factors affecting cost of machines service.

The new custom-rate, wage-rate ratio reported in table 1 reveals a large decline in the relative cost of machinery. With these data, the explanation for farm mechanization becomes straightforward. Farmers demanded new and larger machines because the cost of farm labor, both the opportunity cost of family labor and wage of hired labor, increased relative to the prices of machinery services. Machinery manufacturers responded to this increase in demand by expanding capacity through investment in both research and development and plant and equipment. Thus, as we read the evidence, the technical change that encouraged farm mechanization occurred mostly in the manufacturing sector. Had the induced innovation hypothesis been more carefully formulated in terms of the interrelation between agriculture and manufacturing,[2] we believe that empirical work would have distinguished between internal and external technical change in turn leading to careful quality adjustment of machine price data and in the final analysis would have produced very different findings and policy implications.

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[2] Although Hayami and Ruttan did not distinguish between internal and external technical change, they did adjust for input quality change in their attempt to explain changes in factor proportions in the United States and Japan by changes in factor price ratios (chap. 6).

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The Economic Efficiency of Farmers Growing High-Yielding, Irrigated Rice in India

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The high-yielding varieties program has been operating for some fifteen years in India. As a result, the "modern" technology is no longer a "new" technology, particularly for irrigated rice farmers. The issue addressed in this paper, therefore, is whether farmers producing high-yielding varieties (HYV) of rice are doing so in an economically efficient manner, or do substantial opportunities remain to increase the efficiency of the farmers' application of modern rice technology? To get an empirical answer and to assess better the economic performance of farmers, a study area was chosen to approach ideal field conditions for implementation of the program. Economic performance can be measured by comparing the economic efficiencies of farmer groups (small and large). The profit function developed by Yotopoulos and Lau is used as an analytical tool to examine economic efficiency, including technical and price efficiency.

For the empirical estimation of profit and variable factor demand functions, a random sample of seventy farmers growing a HYV IR20 in rabi (winter) season 1977/78 was selected from a progressive village in the Coimbatore district, Tamil Nadu, a favorably placed area in terms of irrigation, administration, paddy varieties, and other such factors. The total population of the village, Seyyampalayam, consisted of about 55% of farmers having operational holdings of 1 hectare or less with an average of 0.64 hectare; the other 45% had operational holdings of above 1 hectare with an average of 2.79 hectares. Accordingly, equal representation was given to both groups (35 farmers each) in our random sample, defining a larger farmer as one with more than 1 hectare.

Input Availability and Use

The HYV program was introduced to Coimbatore in 1966. Since then there has been a rapid growth of both HYV adoptors and area. IR20 was introduced in 1969/70 and by 1972/73, it was grown almost exclusively in both seasons in the study area, Seyyampalayam. From 1975/76, two recently released location-specific, high-yielding varieties, ADT31 and CO37, gained popularity, replacing IR20 in the kharif season. In rabi season, however, IR20 retained its popularity. Almost 91% of farmers in the study area were growing IR20 during the survey period.

There was almost no input supply shortage reported during this survey. Nor were there any significant differences between large and small farmers in levels of application of inputs in the study area (table 1). All the participants were well served by canal irrigation, and the quantity and timing of water were adequate. Table 1 implies that there were no major constraints in the study area on input availability and use. This supports the findings of Barker and Herdt that small farmers have the same economic motivation as large farmers in adopting HYVs.

Empirical Profit and Factor Demand Functions

Assuming a Cobb-Douglas production function, the estimating equations of profit functions are

$$\ln\Pi = \lambda + \alpha^*_0 D_1 + \beta^*_1 \ln W + \beta^*_2 \ln F + \beta^*_3 \ln P + \beta^*_4 \ln B + \alpha^*_1 \ln A + \alpha^*_2 \ln C,$$

where Π is unit output price (UOP) profit in rupees; W is normalized rate for labor (man days), calculated by dividing the total wage paid to labor by the total number of laborers used all divided by the unit price of paddy; F is normalized fertilizer price, obtained by dividing the total expenditure on fertilizers by the total amount of fertilizer in kilograms and normalizing the ratio by UOP; P is normalized pesticides price, calculated by dividing the total amount spent on pesticides by total amount of pesticides in kilograms, and normalizing this ratio by UOP; B is normalized wage for a bullock pair per day, obtained by dividing the total expenditure on bullocks by the total pairs of bullocks and dividing this ratio by UOP; A is cultivated area in acres; C is capital flow, calculated as the sum of depreciation, maintenance, and opportunity costs of capital stock;[1] $D_1 = 1$ for small farm group, 0 otherwise;

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[1] Depreciation is calculated by the straight line method, and opportunity costs are derived by multiplying the stock by 12%, which was the lending rate of the local cooperative societies.

Table 1. Average Input Applications to IR20 by Farm Size Group, in Rabi Season, 1977/78, and Other Farm Characteristics

	Average Application per Acre		
Inputs/Farm Characteristics	Large Farmers	Small Farmers	T-value
Hired labor (man-days)	187.52	189.14	0.36
Expenditure on pesticides application (Rs.)	98.54	100.34	0.47
Expenditure on other inputs (Rs.)	242.01	217.73	1.10
Nitrogenous fertilizer (kgs.)	41.89	41.63	0.18
Phosphorous fertilizer (kgs.)	18.57	20.57	1.24
Potassic fertilizer (kgs.)	19.03	20.14	0.62
Sample size	35	35	
Average operational holding (ha.)	2.4	0.72	3.75[a]
Yield per Acre (tons)	1.48	1.50	0.20

[a] Significant at the 1% level.

and λ is constant. The variable factor demand functions are

$$\frac{-Wx_1}{\Pi} = \beta^*{}_1{}^S D_1 + \beta^*{}_1{}^L D_2,$$

$$\frac{-Fx_2}{\Pi} = \beta^*{}_2{}^S D_1 + \beta^*{}_2{}^L D_2,$$

$$\frac{-Px_3}{\Pi} = \beta^*{}_3{}^S D_1 + \beta^*{}_3{}^L D_2,$$

$$\frac{-Bx_4}{\Pi} = \beta^*{}_4{}^S D_1 + \beta^*{}_4{}^L D_2,$$

where x_1 is total labor man-days used; x_2, total chemical fertilizer used (kgs.); x_3, total pesticides used (kgs.); x_4, total bullock pair days; S, small farmer group; L, large farmer group; $D_1 = 1$ for small-farm group and zero otherwise; and $D_2 = 1 - D_1$.

Tests for Relative Efficiency

The first hypothesis to be tested is that there is equal relative economic efficiency among the small and large-farm groups in the study area. This requires that the UOP profit functions of small- and large-farm groups and their variable factor demand functions coincide with each other. These enable us to test for the two components of economic efficiency, (*a*) technical efficiency, whereby the greatest output is obtained from any given set of inputs in a technical production function, and (*b*) price efficiency, which involves equality between marginal value products and opportunity costs.

Testing equal relative economic efficiency empirically between small- and large-farm groups involves examining whether parameters of the UOP profit function of small- and large-farms are the same. This is equivalent to testing whether the dummy variable coefficient, $\alpha^*{}_0$, is zero.

The test for equal relative price efficiency between small- and large-farm groups is to examine whether both groups of farmers equate marginal value product to marginal cost of the variable factors to the same degree. This is equivalent to testing whether or not the elasticities of variable inputs of small ($\beta^*{}_i{}^S$) and large ($\beta^*{}_i{}^L$) farms, estimated from factor demand functions, are the same. The null hypothesis can be represented by the following equality:

(1) $$\beta^*{}_i{}^L = \beta^*{}_i{}^S,$$

where i is variable inputs: labor (1), fertilizer (2), pesticides (3), and bullock pair days (4).

A test for equal relative technical efficiency consists of testing the joint hypothesis of equal relative economic and price efficiencies, which is equivalent to testing the following equalities simultaneously:

(2) $$\alpha^*{}_0 = 0 \text{ and } \beta^*{}_i{}^S = \beta^*{}_i{}^L,$$

where $i = 1, 2, 3, 4$.

The next hypothesis to test is whether the farms (small or large) maximize their profits fully, equating marginal value products of the variable factors to market prices specific to these farmers. This is equivalent to testing whether the elasticities of variables factors ($\beta^*{}_i{}^S$ and $\beta^*{}_i{}^L$) estimated from the factor demand functions are equal to the respective elasticities estimated from profit functions ($\beta^*{}_i$); the appropriate null hypothesis is

(3) $$\beta^*{}_i{}^S = \beta^*{}_i \qquad \beta^*{}_i{}^L = \beta^*{}_i$$

where $i = 1, 2, 3, 4$. The above hypothesis concerns the absolute price efficiency of farms.

All hypotheses were tested by incorporating the respective equalities (1) and (3) as restrictions I ($\beta^*{}_i{}^L = \beta^*{}_i{}^S$), and II ($\beta^*{}_i{}^S = \beta^*{}_i$) and ($\beta^*{}_i{}^L = \beta^*{}_i$) in the estimation process. Aitken's generalized least-squares method (ALS) through a Lagrangian multiplier was used so that the estimated coefficients exactly satisfy the conditions imposed by the null hypotheses (Byron). After testing restrictions I and II separately, restriction III ($\beta^*{}_i{}^S = \beta^*{}_i$ and $\beta^*{}_i{}^L =$

$\beta^{*}{}_{i}^{S}$), which involves I and II taken together, was introduced in the estimation process to obtain profit and variable factor demand functions for further analysis. This way of estimating profit and factor demand functions is different from the Yotopoulos and Lau method. The advantage of working with this method is that it is possible to identify which elasticities estimated from the factor demand func-

Table 2. Jointly Estimated Parameters of Normalized Profit Function and Variable Factor Share Functions for Sample Farmers and Statistical Tests

Variable	Parameter	Estimated Values (ALS)		
		Restriction I	Restriction II	Restriction III
Profit function:				
Constant	λ	6.003**[c]	5.7432**	5.6531**
		(0.[illegible]432)[a]	(0.1356)	(0.1260)
Normalized wage	β^{*}_{1}	−0.[illegible]917**	0.5820**	−0.5325**
		(0.[illegible]803)	(0.1935)	(0.1793)
Normalized fert. price	β^{*}_{2}	−1.[illegible]079**	−0.9100***[d]	−0.8626**
		(0.[illegible]560)	(0.4605)	(0.3209)
Normalized pesticides price	β_{3}	−0.0852**	−0.0603	−0.0847
		(0.0325)	(0.0425)	(0.0499)
Normalized animal power price	β^{*}_{4}	−0.1320**	−0.1108***	−0.1006**
		(0.0390)	(0.0564)	(0.0304)
Land	α^{*}_{1}	0.9724*[b]	0.9756*	0.9802*
		(0.1460)	(0.1520)	(0.1407)
Capital	α^{*}_{2}	0.0210**	0.0320**	0.0198**
		(0.0103)	(0.0143)	(0.0093)
D_1	α^{*}_{3}	0.1752	0.1695	0.1532
		(0.2349)	(0.1802)	(0.1903)
Labor share function	$\beta^{*}{}_{1}^{S}$	−0.6210**	−0.5820**	−0.5325**
		(0.2[illegible]04)	(0.1935)	(0.1793)
	$\beta^{*}{}_{1}^{L}$	−0.6210**	−0.5820**	−0.5325**
		(0.2[illegible]04)	(0.1935)	(0.1793)
Lagrange multiplier	λ_{1}	0.9[illegible]69	1.0375	0.9235
		(1.0[illegible]47)	(1.5623)	(0.9872)
Fertilizer share function	$\beta^{*}{}_{2}^{S}$	−0.9[illegible]72**	−0.9100***	−0.8626**
		(0.1[illegible]98)	(0.4605)	(0.3209)
	$\beta^{*}{}_{2}^{L}$	−0.9[illegible]72**	−0.9100***	−0.8626**
		(0.1[illegible]98)	(0.4605)	(0.3209)
Lagrange multiplier	λ_{2}	0.8[illegible]26	1.0730	0.8318
		(1.0[illegible]28)	1.0820)	(1.0032)
Pesticides share function	$\beta^{*}{}_{3}^{S}$	−0.0853**	−0.0603	−0.0796**
		(0.0410)	(0.0425)	(0.0309)
	$\beta^{*}{}_{3}^{L}$	−0.0853**	−0.0603	−0.0796**
		(0.0410)	(0.0425)	(0.0309)
Lagrange multiplier	λ_{3}	1.66[illegible]1	3.9689**	1.7208
		(1.3150)	(1.3204)	(1.5003)
Animal power share function	$\beta^{*}{}_{4}^{S}$	−0.12[illegible]9**	−0.1108**	−0.1006**
		(0.03[illegible]2)	(0.0564)	(0.0304)
	$\beta^{*}{}_{4}^{L}$	−0.12[illegible]9**	−0.1108***	−0.1006**
		(0.03[illegible]2)	(0.0564)	(0.0304)
Lagrange multiplier	λ_{4}	0.22[illegible]1	0.3009	0.2372
		(0.48[illegible]8)	(0.5206)	(0.4600)
χ^2 − test for $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$		6.76[illegible]2	10.8234**	6.0375

[a] Figures in parentheses are standard errors of estimates, and the restrictions are referred in the text.
[b] *significant at the 1% level.
[c] **significant at the 5% level.
[d] ***significant at the 10% level.

tions differ from those of the profit functions. It helps policy makers to identify which of the factors are affecting farmers' decision making.

Results

Table 2 shows that since the coefficient (α^*_0) was not statistically different from zero at the 90% level, there was equal relative economic efficiency in the cultivation of IR20 in rabi season among small- and large-farm groups.

The results of the statistical tests of equal relative price and technical efficiencies are given in terms of λ and χ^2. The analysis showed that the null hypothesis of equal relative price efficiency of small and large farmer groups could not be rejected at the 10% level. The estimates of λ did not significantly differ from zero and the value of χ^2 was not significant. This indicates that the restrictions were satisfied and that there were no differences between price efficiency parameters of small- and large-farm groups. Similarly, the null hypothesis of equal relative technical efficiency between small and large farmer groups could not be rejected.

Because different farmer groups face different input and output prices and have different levels of fixed resources, the input combination that results in perfect (full) maximization will be farmer group-specific. Thus, the necessary and sufficient condition for full maximization is that each group should equate its marginal product of variable inputs to its specific market prices (Yotopoulos and Lau). The results of tests of full profit maximization of the small farmer group and also of the large farmer group showed that the null hypothesis could be rejected. The χ^2 was significant at the 5% level. This implies that both groups did not perfectly maximize their profits in utilization of the variable factors. Both groups were not using variable factors at optimum levels.

With the present method of estimation, it is possible to find out which of the factors were not used as optimum levels and why. Assuming that all restrictions were valid, it was found that the estimate of λ with respect to pesticides, estimated from the factor demand function and profit function, was significant at the 5% level in both cases. The significance of λ in relation to pesticides means that both farmer groups were not able to equate marginal value product and marginal cost for this factor.

This can be explained by the biological characteristics of IR20. It has been shown statistically that the sample farmers were unable to control completely the pest Brown planthopper (BPH), though they applied the recommended doses of pesticides. The main reason is that the maturity period of IR20 (130–35 days) does not enable the pesticides to work effectively on BPH. It coincides with the building up of BPH in the sample village. As a result, the marginal value product of pesticides fell below its marginal cost.[2] Thus, the local pest (BPH) was a disturbing factor affecting the sample farmers' decision making. Except for this constraint, all participants in general were more inclined toward the economic motivation of price taking and maximizing profit. This result conforms with that of Yotopoulos, Lau, and Lin in relation to the agricultural households in Taiwan.

Conclusions

Sample participants can be called economically efficient. This strongly disagrees with the pessimistic view of Hanumantha Rao that HYVs offered greater opportunity to bigger farmers, but it supports the findings of Rajagopalan that small farms have not lagged behind in growing and deriving benefits from HYVs. Parthasarathy and Prasad, with data from the rice-growing areas of Andhra Pradesh in India, also arrived at almost the same conclusion, that the relationship between size and productivity found in the pre-technology period is not apparent. With the exception of BPH control, this study shows that economic opportunities provided by the HYV program were utilized efficiently by sample participants regardless of farm size. Further, they all had the same economic motivation of maximizing profits.

Given the same access to inputs and equal terms, small farmers will respond to economic opportunities in the same way as large farmers. However, in order to achieve this, special institutional arrangements may be necessary to ensure equal access for small farmers to inputs.

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[2] A direct test of equality between *MVP* and MC was not attempted because it requires that all the other inputs be considered at the geometric mean. However, the equality between *MVP* and *MC* can be inferred from the statistical significance of λ.

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The Inverse Relationship between Size of Land Holdings and Agricultural Productivity

Vaman Rao and Tosporn Chotigeat

The important relationship between the size of land holdings and agricultural productivity in developing countries has been debated intensely. From early Soviet debates to the extensive literature generated by the release of Farm Management Survey (FMS) data in India, the question of returns to scale and input productivities (primarily for land) in traditional agriculture has been confused and clouded by strong positions and ideological predilections.

Bhagawati and Chakravarty, Saini (1969), and Bharadwaj provide extensive bibliographies on the theoretical and empirical aspects of this problem in the Indian context. Briefly, Sen (1964, 1966), Mazumdar (1963, 1965), C.H.H. Rao (1966, 1970), Khusro, Saini (1971), Bhattacharya and Saini, more or less endorse an inverse relationship between the land size and its productivity. A. P. Rao (1963) and Rudra and Bandhopadhyay do not believe in the existence of an inverse relationship and argue that no systematic relationship can be established between any two variables describing land size and productivity. Bharadwaj and others dismiss the statistical validity of an inverse relationship, but generally accept it as a "stylized fact."

The approach used in these statistical studies is to employ aggregate, average or farm level data within a village or among different villages for all crops or a few specific ones. Various concepts of productivity and input variables are used. The actual regressions use linear or log-linear functional forms.

Using the pooled FMS data for several states in South India, this paper makes an attempt to reexamine, in a more general way, the relationship between the size of land holdings and agricultural productivity. This study employs the transcendental logarithmic (translog) function to formalize the relation between output and an arbitrary number of inputs. The translog function is not locally constrained by assumptions of homogeneity or additivity. Estimates of output elasticity with respect to land size for various values of cooperating inputs will indicate whether the alleged inverse relationship holds in any or all circumstances.

The Model

The transcendental logarithmic function was chosen as the basic functional form of the model. The properties of the translog function are discussed in Christensen, Jorgenson, and Lau, and Berndt and Christensen. The function is represented by (Model 1),

$$(1)\quad \ln y = \ln \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln x_i + \tfrac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \beta_{ij} \ln x_i \ln x_j + E_i,$$

where y is output, the x_i are inputs, the Greek letters are parameters and $\beta_{ij} = \beta_{ji}$.

In this model the output elasticity with respect to x_{1i} is given by

$$(2)\qquad \eta_i = \frac{\partial \ln y}{\partial \ln x_i} = \alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln x_j,$$

which can be evaluated at given values of x_j, the cooperating inputs. The signed measure of η_i, at different values of x_j, indicates the nature and magnitude of the relationship between the output and a selected input.

The estimation of parameters when using pooled data poses problems of serial correlation and heteroskadasticity. Because the FMS data used in this study are for different regions, different sizes of land holdings, and different time periods, it is reasonable to assume that cross-sectional units are mutually correlated and that there is serial correlation through time. Therefore, generalized least-squares regression was used (Kmenta, p. 512–14). After the initial estimation, if a particular variable was found to be not significant at $\alpha = .05$, it was dropped and the model was reestimated.[1] The choice of the particular set of regressors was based upon intuitive considerations and data availability.

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[1] With this method, R^2 values could not be calculated to determine the goodness of fit. The R^2 calculated by using the sums of squares of regression and error of all the seven time-series combined did indicate that the translog model was a better fit compared to two simple models. The variables were tested for multicollinearity. No serious problems were encountered.

For the purpose of comparison with earlier studies, the following two single-variable and three-variable log-linear models were also estimated: (Models 2 and 3)

(3) $\ln y = \ln a + b_1 \ln x_1 + e,$ and

(4) $\ln y = \ln A = \Sigma B_i \ln x_i + v.$

The Data

For this study, FMS data for Alleppey and Quilon (Kerala) for the years 1962–63/1964–65, for Tanjavur (Tamil Nadu) for the years 1967–68/1969–70 (averages for three years) and for Cuddapah (Andhra Pradesh) for 1967–68/1969–70 were used. Even though the cropping patterns in the three areas are not the same in all details, the main crops (rice and millets), cultivation practices (fertilizers and varieties of seeds), and institutional features (landlord-tenant relations and credit availability, etc.) are not dissimilar. Pooling of data was necessary to obtain a sufficient number of observations.

Six dependent variables were defined which directly or indirectly represent the productivity of land: Y_1 is the gross value of output per cultivated hectare, and Y_2 is the same measure per cropped hectare; Y_3 and Y_4 are farm business income per cultivated and cropped hectare, respectively; Y_5 and Y_6 are net farm business income, respectively, per hectare of cultivated and cropped land. Obviously, Y_1 and Y_2 are measures of physical productivity; Y_3 and Y_4, on the other hand, are measures of profitability obtained by deducting all production costs actually incurred from gross output values. They motivate all farming operations, including decisions such as choice of production techniques. If the rent paid to the landlord for leased-in land also is deducted, then the net farm business income variables, Y_5 and Y_6, are obtained. The last pair is important in considering the effect of land ownership on productivity. All values are expressed in current market prices. Regional disparities in prices are negligible, and year-to-year changes in output prices are not likely to distort the results because they affect all sizes equally. A word about the distinction between the cultivated and cropped areas is necessary, because it has generated controversy in earlier literature. The cultivated area represents the total arable area of land held, including current fallow (usually less than 1%). Multiple cropping generally increases the cropping intensity to more than 1.0. The cropped area, therefore, represents the equivalent of the land used for single cropping. One measure represents the actual size of the holding and the other, the effective size.

Nine regressors have been defined: X_1 and X_2 are two measures of land, X_1 being the average size of the holding and X_2, the average size of a fragment Both are measured in hectares. X_1 represents the average area of an enterprise and possibly could be composed of several noncontiguous fragments. The noncontiguity may make it difficult for the farmer to adopt a production technique appropriate to the size of the holding. X_1, therefore, is not a true indicator reflecting the choice of production technique. Hence, X_2 is a second measure of the land size variable. Labor is measured as man-days; X_3 is total family labor, and X_4 is the total hired labor used per hectare. X_6 represents the current costs on capital equipment, including costs incurred on implements, fertilizers, seeds, irrigation, etc. These costs have been further classified in two ways: X_7 includes capital costs used in traditional methods of farming, and X_8 are costs on capital inputs generally incurred in nontraditional modes of agricultural production. This distinction was arbitrary and followed a common perception of what generally is believed to be traditional versus modern. A second way of classifying the capital costs was on a functional basis. Capital inputs that performed the functions of land were included in X_9, and those that displaced labor were included in X_{10}. Fertilizers and high-yielding variety seeds are the examples of the former, and improved ploughs and tractors are the examples of the latter. In effect, all the nine regressors represented different aspects of land, labor, and capital.

The Results

The estimated coefficients of model 2 (not reported) revealed that there is no systematic pattern of relationship between the land size and productivity. Average size of holding (X_1) was found to be significantly related only with net farm business income per cultivated hectare (Y_5). Similarly, average size of fragment (X_2) displayed a significant relationship with net farm business income (Y_5, Y_6). These relations were inverse, even though Khusro and Mazumdar (1963, 1965) argue that there is a positive relation between land size and farm business income. The only other significant relationship was between average size of fragment (X_2) and gross value of output per cultivated hectare (Y_1). This was also positive, rather than inverse. The coefficients of model 3 (not reported) had much the same story to tell.

The coefficients of the translog model, reported in tables 1 and 2, make it clear that the relationship is much more complex than is reflected by the simple models. It is also clear that there is not a systematic relationship between all the measures of productivity defined in this study and land size. However, in cases where the relationship can be systematically explained, the separate effect of land alone is not always significant. But land size does significantly explain variation in productivity in association with other inputs. Therefore, the negative signs associated with the coefficients of X_1 and X_2,

Table 1. Translog Regressions (Model 1)

	ln Y_1		ln Y_2		ln Y_3	
ln X_1	*[a]		*		−.398	(4.60)
ln X_3	*		*		−.751	(5.79)
ln X_6	.954	(5.63)	.765	(4.79)	.687	(5.86)
ln X_1 ln X_3	.179	(3.48)	.206	(3.61)	.149	(5.67)
ln X_1 ln X_6	−.179	(3.74)	−.118	(2.42)	*	
ln X_3 ln X_6	−.468	(3.69)	−.407	(2.92)	−.566	(4.90)
(ln X_1)^2	*		−.041	(2.49)	*	
(ln X_3)^2	.276	(4.13)	.307	(4.34)	.590	(6.55)
(ln X_6)^2	.183	(5.22)	.122	(2.70)	.147	(4.12)
Intercept	2.306	(38.32)	2.492	(35.16)	7.126	(24.85)

[a] Asterisk indicates the variable not significant at 5% level of significance. Such variables were eliminated before these coefficients were estimated. The figures in parentheses are t-values.

while important, should not be taken to reflect the total relationship between the land size and productivity. The signs of multiplicative terms are mathematically consistent with the signs of the individual terms.

The total relationship can best be explained by output or business income elasticities computed at given values of other inputs, table 3. For this paper, the maximum, the average, and the minimum values of cooperating inputs from the sample data are used. The sign of the elasticity measure depends on the signs of the estimated coefficients and the values of the cooperating inputs. An analysis of these signs will show the role of the cooperating inputs in the overall relationship.

The elasticity of Y_1 with respect to X_1 diminishes as the values of cooperating inputs are increased, ultimately reaching a negative value. This means the gross value of output per cultivated hectare increases at a diminishing rate with average size of holding when more and more units of cooperating inputs are used. At maximum values of both cooperating inputs, larger average size of holdings generate lower gross value of output per cultivated hectare. The signs of the estimated coefficients suggest that capital (X_6) has a consistent positive effect and labor (X_3) and land (X_1) have consistent

Table 3. Output or Business Income Elasticities

	With Minimum Values of Cooperating Inputs	With Average Values of Cooperating Inputs	With Maximum Values of Cooperating Inputs
Y_1 wrt X_1	.3808	.0314	−.0719
Y_2 wrt X_1	.2829	−.2345	.2837
Y_3 wrt X_1	−.4097	.0399	.4263
Y_1 wrt X_2	.2843	.0383	.1490
Y_2 wrt X_2	.5023	1.1665	1.1892
Y_3 wrt X_2	−.1858	−.1250	.2467
Y_6 wrt X_2	.3527	−.0130	.1271

negative effects on the elasticity measure. The net effect, however, depends on the individual effects acting in conjunction with one another. Thus, large doses of capital and small doses of labor acting in opposition to one another will insure a positive relation between land size and productivity, as measured by gross value of output per cultivated hectare.

The elasticity of Y_2 with respect to X_1 first diminishes and then increases as both cooperating inputs are increased. This peculiar effect is the net result of positive effects of capital and negative effects of labor and land. As the doses of labor and capital are increased, the larger negative effect of land and labor dominates the smaller positive effect of capital. But with larger doses of capital, the dominance is gained by capital, finally resulting in a positive measure of elasticity. When farms are multiple cropped, large amounts of capital and labor ensure a positive size-productivity relation.

The elasticity of Y_3 with respect to X_1 is negative with minimum and average values of cooperating inputs, but it becomes positive at maximum values. This relationship confirms the positive relationship suggested by earlier studies between land size and profitability. The elasticity of several measures of productivity with respect to average size of fragment also can be explained similarly since they

Table 2. Translog Regressions (Model 1)

	ln Y_1		ln Y_2		ln Y_3		ln Y_6	
ln X_2	−.360	(4.01)	−.169	(1.84)	−.818	(4.90)	−.558	(2.08)
ln X_3	*[a]		*		−2.063	(4.76)	−1.428	(2.08)
ln X_6	.849	(6.79)	.607	(4.66)	1.197	(4.95)	−.987	(3.14)
ln X_2 ln X_3	.426	(4.23)	.409	(3.75)	.525	(3.17)	.595	(2.18)
ln X_2 ln X_6	−.294	(3.97)	−.231	(2.94)	−.291	(2.46)	−.414	(2.06)
ln X_3 ln X_6	−.758	(5.14)	−.619	(4.07)	−1.117	(4.24)	−.942	(2.55)
(ln X_2)^2	*		−.099	(3.20)	*		*	
(ln X_3)^2	.491	(5.88)	.486	(5.68)	.927	(5.09)	.733	(3.15)
(ln X_6)^2	.289	(6.56)	.220	(4.70)	.363	(4.23)	.281	(3.41)
Intercept	2.229	(37.73)	2.298	(30.32)	6.540	(32.66)	6.569	(18.60)

[a] Asterisk indicates the variable not significant at 5% level in the fuller model. Such variables were eliminated before the above coefficients were estimated. The figures in parentheses are t-values.

follow the general pattern suggested by average holding size.

In summary, capital has a positive effect and land and labor negative effects on the elasticity of gross value of output per unit of land. However, large doses of capital can compensate for the negative effects and a positive total relation between land size and productivity can be obtained. This result is of considerable significance when analyzing the choice of techniques in India's agricultural sector. Large-sized farms with capital-intensive techniques can obtain higher productivity with increased land holdings, especially with multiple cropping.

A further analysis was carried out to examine the relative importance of different types of labor and capital. The computation of elasticities revealed that for farm business income, the larger the component of hired labor and the smaller the component of family labor, the larger is the elasticity with respect to land size. Similarly, the larger the component of nontraditional capital equipment, or the smaller the component of traditional capital equipment, the larger is the business income elasticity with respect to land. Larger sizes of labor-saving capital or smaller sizes of land-saving capital will also increase the measures of both output and business income elasticities with respect to land size.[2]

The results suggest that larger-sized land holdings are not less productive, in all circumstances, as may be generally believed. If hired labor is employed in preference to family labor and if more nontraditional capital as opposed to traditional capital is used, larger-sized holdings and higher productivity can go together.

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A General Measure for Output-Variable Input Demand Elasticities

Barry C. Field and P. Geoffrey Allen

In recent years the development of new production function forms has given impetus to empirical work of measuring input demand and substitution elasticities in a variety of industries. The so-called "flexible" functional forms have given us a much richer set of tools to investigate these relationships, as compared to the familiar Cobb-Douglas and constant-elasticity-of-substitution functions. The majority of researchers have reported their results in terms of input parameters estimated under the assumption of fixed output. While this is appropriate for some questions, we argue in the next section that output-variable measures often will be more useful for the problem at hand. In the third section, we derive a general expression for the output variable price elasticity of input demand, of which the well-known expression of Allen is a special case. Last, we discuss this measure in the context of several specific functional forms.

The Question of Output Variability

Although a bewildering number and variety of input substitution and demand parameters have been put forth by researchers, perhaps the most widely used measure is the simple price elasticity of input demand:

$$\epsilon_{ij} = \frac{\partial \ln X_i}{\partial \ln P_j} \bigg| \; Q, P_k \text{ for all } k \neq j,$$

where X_i is the quantity demanded of the ith input, P_j the price of the jth input, and Q refers to total output. To be consistent with demand theory, this is the elasticity whose sign should determine whether an input pair are substitutes or complements. It also may be expressed in a slightly different form: $A_{ij} = \epsilon_{ij}/S_j$, where S_j is the share of the jth input in total cost. A_{ij} is the Allen-Uzawa partial elasticity of "substitution," so called despite the fact that it is simply a normalized price elasticity of demand.

The elasticity ϵ_{ij}, calculated under the assumption that output is held constant, can indicate the characteristics of particular production surfaces that influence policy direction, i.e., the matter of substitutability and complementarity among inputs. Combinations of ϵ_{ij} also can be used to construct higher-order elasticities of substitution to study the curvature properties of production surfaces.

For matters of public policy, however, the assumption of constant output is often a disadvantage. There we are usually concerned with measuring the consequence of particular actions; for example, the effects of given subsidies on capital, of limits on land inputs, or of increases in energy prices. To be complete, we must take into account both input substitutions along given isoquants and the effects of output changes on input demand. What are needed in this case are measures of total elasticity:

$$\eta_{ij} = \frac{\partial \ln X_i}{\partial \ln P_j} \bigg| \; P_k \text{ for all } k \neq j.$$

In this case, quantities of all inputs as well as output are allowed to adjust to input price changes.

The expression that results, equation (4) below, is similar to the Slutsky equation of consumer demand theory. Thus, the general measure is somewhat analogous to the difference between ordinary and compensated demand curves in consumer behavior. The ϵ_{ij} above are analogous to elasticities on the compensated demand curve; whereas, for predicting real-world changes in consumption, we wish to know the elasticities of the ordinary demand curves. For most goods it will not make much difference which measure is used because consumers normally will spread their incomes over a large number of goods. On the production side, however, this is not the case. Most production functions contain only three or four measured inputs. For many of these inputs, therefore, the difference between elasticities with and without an output effect could be considerable.

One output-variable input demand elasticity already is available. In the case of constant returns to scale (CRTS) in production but a downward sloping output demand function, changes in output are produced when the cost function shifts, the extent of the output change being related to the price elasticity of output demand. This total input demand elasticity was provided by Allen (p. 508). Output effects also can be produced, even with a constant output price, if the production function is non-

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CRTS. In this case, shifts in a sloping cost (supply) curve over a horizontal demand curve produce changes in output. Of course output effects could result from both a downsloping output demand function and non-CRTS in production. In the next section we derive a general expression for the output-variable elasticity of substitution.

A General Expression

To derive a general expression for η_{ij}, i.e., one that permits both nonconstant returns and nonconstant output price, we make use of the following relations: production function $Q = f(X)$, dual minimum cost function $C = C(P,Q)$, and demand function $Q = \phi(R)$, where X and P are n-tuples of input quantities and prices, respectively, Q is output, and R is output price. Market clearing requires that marginal cost equal output price, or

$$C_q(P,Q) = \phi^{-1}(Q). \tag{1}$$

We use subscripts to denote partial differentiation with respect to that variable. By differentiating (1) totally, setting $dP = 0$ for all but the jth factor price and rearranging, we get:

$$\frac{\partial Q}{\partial P_j} = \eta \quad \frac{C_{qj}Q}{(R - C_{qq}Q\eta)},$$

where $\eta = \partial \ln Q/\partial \ln R$, the price elasticity of demand for output.

According to Shepard's lemma, $\partial C/\partial P_i = C_i = X_i(P,Q)$, the cost-minimizing demand curve for input i. Differentiating this demand curve with respect to the jth factor price gives

$$\frac{\partial X_i}{\partial P_j} = C_{ij} + C_{iq}\frac{\partial Q}{\partial P_j}. \tag{3}$$

Using (2) and substituting appropriately gives[1]

$$\eta_{ij} = \left.\frac{\partial \ln X_i}{\partial \ln P_j}\right|_{P_k,\, k \neq j} = S_j(A_{ij} + \eta\psi) = \epsilon_{ij} + S_j\psi\eta,$$

where $S_j = P_jX_j/C$, the share of the jth input in total cost; $A_{ij} = CC_{ij}/C_iC_j$, the Allen-Uzawa elasticity of "substitution" expressed in terms of the cost function, and

$$\psi = \frac{C_{iq}C_{jq}Q^2}{C_iC_j(1 - R^{-1}C_{qq}Q\eta)}.$$

Suppose we have a downward sloping demand curve: $0 < |\eta| < \infty$, and CRTS. In this case, marginal cost is constant, or $C_{qq} = 0$, giving

$$\psi = \frac{C_{iq}C_{jq}Q^2}{C_iC_j} = 1$$

since CRTS implies $C_i = QC_{iq}\ \forall\ i$. This gives the expression derived by Allen (p. 508):

$$\eta_{ij} = S_j(A_{ij} + \eta). \tag{4}$$

There are two cases where the expression gives constant-output elasticities, either CRTS ($C_{qq} \to \infty$) or a perfectly vertical demand curve ($\eta = 0$).

The case that has not been considered before is that characterized by $\eta \to -\infty$ and $C_{qq} > 0$, where the output effect is produced by the shifting of a sloping supply curve over a horizontal demand curve. In this case,

$$\lim_{\eta \to -\infty} (\eta\psi) = -A_{ij}\frac{C_{iq}C_{jq}}{C_{ij}C_{qq}},$$

giving

$$\eta_{ij} = S_jA_{ij}\left(1 - \frac{C_{iq}C_{jq}}{C_{ij}C_{qq}}\right). \tag{5}$$

Special Cases

It is of interest to consider the case of an output-price-constant, quantity-variable elasticity, equation (5), in the case of specific production function forms. Several recent studies (Sidhu and Baanante; Yotopoulos, Lau and Lin) have used a non-CRTS Cobb-Douglas function: $\ln Q = \Sigma_i\alpha_i \ln X_i$, with, of course, $A_{ij} = 1$, and $\Sigma\alpha_i = \mu < 1$.[2] In this case, making appropriate substitutions into (5), and recognizing that $\alpha_j = S_j/\mu$,

$$\eta_{ij} = -\frac{\alpha_j}{1 - \mu},$$

a result that was derived originally by Lau and Yotopoulos. Note that, as long as decreasing returns to scale pertain (i.e., $\mu < 1$), all inputs will be judged "complements" ($\eta_{ij} < 0$) despite the fact that $A_{ij} = 1\ \forall\ i, j$. This is another manifestation of the Cobb-Douglas inflexibility.

In the case of a multiple-input CES function,

$$Q = (\Sigma_i\alpha_iX_i^{-\beta})^{-\frac{\mu}{\beta}},$$

with a cost function of

$$C = Q^{\frac{1}{\mu}}\left(\Sigma_i\alpha_i^{\frac{1}{1+\beta}}P_i^{\frac{\beta}{1+\beta}}\right)^{\frac{1+\beta}{\beta}},$$

we have

$$\eta_{ij} = S_j\sigma\left(1 - \frac{1}{\mu}\right),$$

[1] This step makes use of the zero-profit condition, $C = RQ$, and of the symmetry conditions, $C_{ij} = C_{ji}$ and $C_{qi} = C_{iq}$.

[2] The non-CRTS functions in these studies involved subsets of inputs from overall functions that are CRTS. Suppose, on the other hand, we have an overall function that is non-CRTS but has a subset of inputs that are CRTS (when all inputs not in the subset are held constant). Then the elasticities of equation (4) apply only to this subset of inputs and are constructed from shares, S_j, Allen partial elasticities, A_{ij}, and "output" elasticities that refer to this subset of inputs. Of course, to analyze an overall production function in which some inputs are fixed and some variable would require a different analysis than that presented above.

where $\sigma = \dfrac{\beta}{1+\beta}$. Finally, suppose we have a translog cost function:

$$\begin{aligned} \ln C = {} & \ln\alpha_0 + \Sigma_i\alpha_i \ln P_i + \alpha_q \ln Q \\ & + 1/2\Sigma_i\Sigma_j\gamma_{ij}\ln P_i \ln P_j + \\ & \Sigma_i\gamma_{iq}\ln Q \ln P_i + 1/2\gamma_{qq}(\ln Q)^2, \\ & i, j = 1, \ldots, n. \end{aligned}$$

In this case,

$$\eta_{ij} = S_j A_{ij}\left[1 - \frac{(\gamma_{iq} + S_i S_q)(\gamma_{jq} + S_j S_q)}{(\gamma_{ij} + S_i S_j)(\gamma_{qq} + S_q^2)}\right],$$

where

$$\begin{aligned} S_i &= \alpha_i + \Sigma_k\gamma_{ik}\ln P_k + \gamma_{iq}\ln Q, \text{ and} \\ S_q &= \alpha_q + \Sigma_k\gamma_{kq}\ln P_k + \gamma_{qq}\ln Q. \end{aligned}$$

If factors i and j are substitutes, then $(\gamma_{ij} + S_iS_j) > 0$. Furthermore, positive marginal cost, monotonicity, and decreasing returns to scale imply that $S_q > 0$, $S_i, S_j > 0$, and $\gamma_{qq} > 0$, respectively. Homotheticity requires that $\gamma_{iq} = 0 \;\forall\; i$. In this case, the output variable elasticity will be less than the output constant elasticity (i.e., $\eta_{ij} < S_jA_{ij}$). It need not be always negative, however, as is the case with the *CD* function. If the function is sufficiently nonhomothetic, the "output" effect could lead to $\eta_{ij} > S_jA_{ij}$. If total output decreases as the supply function shifts up (assuming decreasing returns to scale), nonhomotheticity of the right type and magnitude (say γ_{iq}, strongly negative while γ_{jq}, close to zero) could give larger output-variable elasticities than output-constant elasticities. In this case the "warping" of the isoquants is strong enough to offset the impact of the change in output.

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Capital Asset Pricing and Farm Real Estate: Comment

Colin Carter

In a recent issue of this *Journal*, Barry employs the capital asset-pricing model (CAPM) to explain farm real estate returns in the context of a well-diversified market portfolio. He finds that a significant portion of returns to farmland are not explained by his model and they can therefore be classified as "nonmarket" returns. The two major claims of his paper are that it provides evidence that farm real estate has low risk relative to other assets and that the CAPM framework provides insights into the effects of nonfarm investor behavior. Empirical support is provided by Barry for the former and little or no discussion is offered by him in relation to the latter. The purpose of this comment is to suggest that farmland returns are not dictated by returns in a portfolio comprised of bonds, stocks, and farmland, and it is unsuitable to investigate them with the CAPM model which assumes they are.

In an equilibrium setting, the CAPM develops a measure of the risk of an asset and the consequent relationship between the asset's risk and its one-period expected return. The major result of the CAPM is often expressed as

$$E(R_j) - i = \beta_j[E(R_m) - i], \tag{1}$$

where $E(R_j)$ is expected return on asset j; i, return on a riskless asset; β_j, cov $(R_j, R_m)/\text{var}(R_m)$; and $E(R_m)$, expected return of the efficient portfolio.

Even though the characteristics of common stocks and investors in these stocks come reasonably close to satisfying the assumptions of the CAPM,[1] the model has been criticized heavily for its limited operational usefulness when used to explain returns on these financial assets. For example, Roll recently has questioned the validity of the CAPM because, he argues, it has never been empirically validated. This questions the application of such a model to a nonfinancial asset such as farmland, which is noted for its indivisibility and illiquidity. Simply stated, farmland comes a long way from satisfying the CAPM assumptions. Because farm real estate is not a financial asset in the traditional sense of the word, it is tenuous to argue that its equilibrium returns will adjust to a level that reflects the risk it contributes to an efficient market portfolio of all financial assets.

The market index in the CAPM is designed to reflect the wealth composition of the representative investor under consideration. Because Barry is investigating nonfarm investor behavior, the market index he constructed should not contain a significant amount of farm real estate. Augmenting his stock and bond index with a farm real estate price index is not a true representation of nonfarm wealth. Furthermore, some farm real estate is implicit in the Standard and Poor 500-stock index to begin with. It is not surprising that Barry estimates a national beta (β) value of .19 for farm real estate returns since his estimate was formed by regressing real estate returns on a wealth index which was explicitly designed by him with .18 real estate returns. That is, the estimated beta value is simply a reflection of the 18% weight he gave farmland in his index of wealth (the independent variable R_m). He undoubtedly would have increased the estimated beta value if he had increased the proportion of the market index represented by farm real estate and vice versa if he had decreased the proportion.

Table 1 reports annual percentage returns in the farmland market and the stock market for the years 1956–73. The farmland returns represent changes in land values only. Over the twenty-three-year period, farmland returns were always positive and averaged 8% per annum, with a coefficient of variation of 6%. On the other hand, returns in the stock market were much more irregular and much more volatile. They averaged 4% per annum, with a coefficient of variation of 27%. These aggregate data indicate that farmland is not a risky investment in relation to financial assets such as common stocks. The data question Barry's initial assumption that a risk premium is required to encourage investors to hold farmland.

Using the ordinary least squares technique, the farmland returns from table 1 were regressed on the common stock returns. The estimated beta value was −.1 and was found not to be statistically different from zero at the .05 level as the t-statistic was −1.2. Thus, farm real estate returns are independent of common stock returns (i.e., their beta value was approximately zero). The zero beta asset does not contribute to the diversification of the total stock portfolio, and hence its inclusion in a nonfarm investor's portfolio cannot be justified. Therefore,

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[1] The critical assumptions of the CAPM are that any investor can borrow or lend as much as he or she desires at the risk-free rate, each investor is a risk-averse utility maximizer, and investors agree about the distribution of the end-of-period asset values.

Table 1. Annual Percentage Returns on U.S. Farm Real Estate and on the Standard and Poor's Index of Common Stocks, 1956–78

Year	Farm Real Estate Returns[a]	Standard and Poor's Common Index (500 Stocks) Returns[b]
1956	.05	.15
1957	.05	−.05
1958	.07	.04
1959	.06	.24
1960	.01	−.03
1961	.03	.19
1962	.06	−.06
1963	.07	.12
1964	.06	.16
1965	.06	.08
1966	.09	−.03
1967	.07	.08
1968	.06	.07
1969	.04	−.01
1970	.03	−.15
1971	.06	.18
1972	.11	.11
1973	.20	−.02
1974	.20	−.23
1975	.12	.05
1976	.17	.17
1977	.11	−.04
1978	.12	−.02
Average	.08	.04
Standard deviation	.05	.11

[a] Annual percentage change of index numbers of average value per acre, United States. Source: USDA.
[b] Annual percentage change of Standard and Poor's common stock index. Source: U.S. Department of Commerce.

even if farmland could be viewed as a financial asset, it would be a riskless asset.

The positive and statistically significant alpha values estimated by Barry imply that farm real estate has offered substantial return premiums above those dictated by the market. This result indicates that investment in farm real estate "outperformed" the market. Does this imply that farmland is severely underpriced or does it indicate the inappropriateness of the CAPM model, equation (1)? Barry does not address this question. The most plausible hypothesis seems to be the inappropriateness of the CAPM, for reasons given above.

Unlike industrial real estate, farmland has not been a risky investment for nonfarm investors. Barry has applied the CAPM to estimate risk premiums required to hold farm real estate in a well-diversified market portfolio. He has assumed implicitly that farmland is not only as liquid as any financial asset, but also that it is a risky asset.

This comment is concerned with the use of the CAPM for the purpose of valuing farm real estate and it points out that farm real estate adds nothing in the way of diversification to a standard market portfolio because farm real estate is virtually a riskless asset.

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Capital Asset Pricing and Farm Real Estate: Reply

Peter J. Barry

The major purposes of Colin Carter's "Comment" on my article are "to suggest that farmland returns are not dictated by returns in a portfolio comprised of bonds, stocks, and farmland, and it is unsuitable to investigate them with the CAPM model which assumes they are." His discussion includes the following items: (*a*) effects of nonfarm investor behavior, (*b*) CAPM applicability to farmland, (*c*) composition of the market portfolio, and (*d*) a numerical illustration of the correlation between changes in values of farmland and common stock. My "Reply" responds to these four items and raises some concerns about several points in his paper.

Carter characterizes my study as ". . . investigating nonfarm investor behavior . . . " and claiming that the ". . . CAPM framework provides insights into the effects of nonfarm investor behavior." This interpretation is too strong. My study was not designed to evaluate the behavior of nonfarm investors. While concern with nonfarm investment in agriculture helped to motivate the study, the analytical approach simply used the CAPM to estimate risk premiums required to hold farm real estate in a well-diversified market portfolio. The empirical results indicated that investment in farmland is a favorable source of diversification for well-diversified investors, which may strengthen the nonfarm sources of demand for investment in farmland. I also suggested, in a general appraisal, that the CAPM's equilibrium framework for risk pricing may have rich implications for future analyses of investor behavior, market characteristics, and policy issues in agriculture.

The second item is Carter's concerns about the CAPM's limited applicability to a nonfinancial asset like farmland and about my alleged failure to evaluate this applicability. Indeed, in the relatively short space of my article, I developed as fully as possible the prevailing mixture of views on the CAPM's usefulness, and identified from CAPM theory several sources of bias in its application to farm real estate. In particular, I inferred from Levy's theoretical analysis that CAPM results for farm real estate may understate the true beta values and overstate the true alpha values. These biases arise from the CAPM's restrictive assumptions about characteristics of investors and markets for farm real estate. They include the combined effects of limited diversification, high transactions costs, tax obligations, indivisibilities, thin markets, and other liquidity characteristics of farm real estate. Hence, I did address these issues, and still concluded in a positive light that farm real estate has low risk relative to other investments, and that the CAPM framework may prove useful for other analyses in agriculture.

The third item is Carter's contention that the market portfolio should not include the asset (farm real estate) whose risk-return characteristics are being evaluated. As pointed out in my article and verified in the finance literature, a basic CAPM principle is that the market portfolio should contain values of all assets that contribute to wealth. Included would be corporate securities, other financial assets, personal assets such as real estate, assets held by unincorporated businesses, human capital, and so on. Because the true market portfolio and its rate of earnings are impossible to measure, CAPM applications use various indexes as market proxies. Most indexes are narrowly defined; an example is a stock market index like the Standard and Poor's 500.

However, analyses with more broadly defined market indexes are becoming common. Sharpe, for example, used a composite stock and bond index in a CAPM application to bond investments. So did Friend, Westerfield, and Granito. Hohlthausen and Hughes indicated the need to use a combined stock and commodities index, although the absence of appropriate weights for stock and commodities precluded its use. CAPM results for a more comprehensive market index are reported by Ibbotson and Fall. They formulated a "market wealth portfolio" based on annual values of common stock traded on the major stock exchanges and over-the-counter, corporate bonds, commercial paper, short-and long-term municipal bonds, four types of U.S. government securities, farm real estate, and residential housing. Their results at the national level over the 1947–78 period gave a beta value of .10 and an alpha value of 4.33 for total real estate, which conform closely to mine.

Thus, CAPM theory and empirical studies give strong support for using a broadly defined index for the market portfolio. From a technical standpoint, however, Carter is correct that including the asset being evaluated in the market portfolio should increase the beta value. In my study, regressions of excess returns to farm real estate on the stock index alone and on the stock and bond index yielded beta values of .08 and .12, respectively, which are below the beta of .19 for the combined index of stock, bonds, and farm real estate. However, it is not clear

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why Carter expresses an element of "surprise" about the beta of .19 from the combined index. The estimated level of beta signifies the magnitude of relationship between changes in excess rates of return on farm real estate and changes in excess returns on a market index that contained on average about 18% farm real estate over the study period. While a relatively low beta value was anticipated, there was no cause for nonsurprise along the lines suggested by Carter. What "surprise" would occur if the beta were 1.5, 2.0, or some other value?

The final item concerns Carter's numerical example, which appears to illustrate the degree of correlation between changes in values for aggregates of two assets: common stock and farmland. The degree of correlation is found not to differ from zero. There is no basis for attributing this relationship to a CAPM application. Rather, the zero correlation simply implies that these farmland returns are independent of common stock returns. As in any portfolio analysis, zero correlation between two assets means that an investor may gain stability by diversifying his holdings to include the two assets, although in this case farm real estate is more risk efficient than common stock. Carter's suggestion that farmland be regarded as a riskless asset in relation to common stock is interesting. The opposite suggestion could occur too: that common stock be regarded as a riskless asset in relation to farmland.

Carter's figures for coefficients of variation (CV) also appear incorrect. Based on the statistics in table 1 of his comment, the CV values are .625 for farm real estate and 2.75 for common stock. Finally, the reference to differences in risk between investments in industrial real estate and farmland is unverified.

In conclusion, I appreciate Carter's comments and hope that my replies shed further light on risk pricing of farm assets relative to other assets. Moreover, to reiterate earlier comments, I believe that the CAPM offers a broad and rich framework for considering the effects of investor behavior, market characteristics, and public policies on risk pricing.

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Books Reviewed

Burns, Joseph M. *A Treatise on Markets: Spot, Futures and Options.* **Washington, D.C.: American Enterprise Institute for Public Policy Research, 1979, 145 pp., $5.25 paper.**

This work is heralded as extending the ideas of Marshall on spot markets and those of Keynes and Hicks on futures markets, and adding a theory of option markets. The central theme is that futures markets typically develop in response to economic forces in spot markets. In turn, futures markets facilitate the work of spot markets. Option markets typically develop in response to forces in spot and/or futures markets and, in turn, help spot and futures markets work better.

In a chapter on "Spot Markets" Burns argues that market efficiency means improved "market liquidity," more "orderliness of market conditions" and better "quality of market organization." Liquidity (the most important of the three) is a function of (*a*) the certainty of the expected value of the asset and (*b*) its expected marketability. (It would have been helpful here if the author had considered Hicks' 1962 article on "Liquidity," containing this formulation). Disorderly markets are those whose prices are monopolized or are made artificial by false rumor or by overreaction of traders. Improved quality of market organization results from more specialization and economies of scale in the conduct of exchange. While liquidity begets orderliness of markets and improves market organization, the influences also run from each of the latter to improved liquidity.

Continuing Burns' discourse, the greater the number of kinds of related markets, the larger are likely to be the induced effects of more efficient markets. Thus, market development in an advanced economy may have immense economic benefits. In particular, futures markets make for more efficient spot and forward markets, encouraging their decentralization and, therefore, more accurately reflect local supply and demand conditions. Local prices, which may seem erratic, actually become more flexible and competitive. The new futures trading in financial instruments and foreign currency likely will yield the most pronounced benefits because their underlying spot markets touch all economic activity.

Futures markets, analyzed in the next chapter, contribute uniquely to market efficiency. Observable prices convey information about unobservable prices. The better futures estimate later spot prices, the better the information. Burns then elaborates on the familiar Keynes-Hicks' idea of "normal backwardation" as a reflection of the cost of price insurance to hedgers—material borrowed from his earlier work. He gives reasons this formulation still holds despite the rising importance of long hedging.

Curiously, Burns does not examine the evidence for a downward bias in futures prices, which evidence should exist if the Keynes-Hicks formulation were vital. More important, he does not recognize that for most commodities, futures trading establishes spot-forward price spreads that embody market-determined prices for services required to handle, store, process, and/or transport commodities—a better documented phenomenon than most that are advanced in the chapter on futures trading. The implicit prices influence the organization of production and the structure of business enterprise, a proposition that is basic to understanding what futures trading in commodities is all about. This curious gap might be explained by Burns' professional grounding in financial (rather than commodity) markets wherein spot-forward spreads can have no such meaning.

A chapter on option markets explains their nature, origins, behavior, and benefits. Many ideas abound. Again, a notable gap is the idea that option contracts are particularly suitable to commodity producers who face great output risk.

A chapter on market regulation argues that controls should "assure that orderliness of market conditions and quality of a market's organization . . . are at a level warranted by the given market's liquidity" (p. 89), e.g., thin markets should receive no special regulatory attention. The influences of false rumor and destabilizing trading are not serious problems because most futures markets are quite liquid. Duplicative trading facilities could become a serious problem because they tend to reduce liquidity. Burns' greatest concern is that foreign governments might manipulate U.S. futures markets, and he considers remedies. An appendix discusses exchange rates, tax straddles, and equity futures.

Burns surely is right in saying that few studies have examined futures and option markets in a market development context. His idea-packed work, written while he was the chief research economist for the Commodity Futures Trading Commission, is indeed welcome. It will stimulate thinking in important and controversial areas. But, it suffers from one general weakness. Too few distinctions are drawn between statements that are pure conjecture, hypotheses suggested by limited evidence, and conclusions based solidly on objective observation. Hence, some readers will be misled on what we really know and others will dismiss too much as dogma of a free marketeer. Yet, well-informed students of markets should be able to pick their way through these traps and garner enough food for thought to make a reading of the monograph worth their time.

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Crotty, Raymond, *Cattle, Economics and Development*. Farnham Royal, Slough: Commonwealth Agricultural Bureaux, 1980, xv + 253 pp., £18 from CAB.

This study focuses on the role of cattle and water buffalo in a variety of settings where these animals play a significant role in the rural economy and provide outputs with economic, social, and cultural significance. The basic theme is that the interaction of capitalistic institutions with communal grazing land results in overexploitation of land, resulting in the gap in animal productivity that exists between wealthy countries (DCs) and less developed countries (LDCs). This problem is accentuated by technology transfer from DCs, particularly medical practices which have increased the population of cattle and humans and has disturbed the delicate balance between man, herds, and grazing resources.

As a prelude to the model of decision making by cattle keepers, the author provides an introduction (chap. 1), a statistical review of livestock numbers and productivity (chap. 2), historical aspects of resource use and agricultural transformation in a variety of agrarian societies (chap. 3), and demand relationships for livestock products (chap. 4). The model, developed in chapter 5, consists of three activities, six resources, and four outputs. A Cobb-Douglas function is used to establish the productivity conditions which are solved for net revenue maximization using five nonlinear simultaneous equations. The next chapters apply the model to:

Region	*Grazing Situation*	*Major Products*
W. Europe, N. America, pre-WW II	Individual grazing	Milk
W. Europe, N. America, post-WW II	Individual grazing	Milk and calves
Latin America	Individual grazing	Calves
Africa	Communal grazing	Milk and calves
Southeast Asia	Communal grazing	Calves
India	Communal grazing	Milk

In this schema, individual grazing refers to individual land use rights and "calves" implies growing out calves for beef. The overriding problems of each of the last four systems are identified and analyzed using the model. The author convincingly argues the reasons conventional development and lending programs have had limited success and, in some situations, have exacerbated the fundamental imbalances. Specific examples serve to document the arguments and a case study in the appendix provides additional material. Recommendations center around (*a*) how to reduce grazing intensity to socially optimal levels through livestock head taxes, (*b*) how to allocate tax receipts to local communities to increase animal productivity, and (*c*) how to allocate cattle investments to achieve productivity and equity goals.

The general problem with the book is that Crotty, under the guise of providing historical and institutional background material, brings in too much extraneous material. Themes that keep reoccurring include agrarian aspects of Irish colonial history, the selective impact of capitalistic institutions on colonial societies, the center-periphery debate on Latin American underdevelopment, the extent of lactose intolerance in LDCs, human population theory, and the high price of straw in India. Also, in studies where vast heterogenous regions are lumped together, some errors of omission are inevitable. The sections on Southeast Asia and India are the worst in this regard. Some errors of logic, unsupported by empirical facts, also occur. Examples include statements that the more valuable land becomes relative to other resources, the less pressure owners have to use it efficiently (p. 92) and higher food prices in Latin America lead to increased political instability and less investment in, and production from, agriculture (p. 101).

The concluding chapter goes far beyond simply summarizing the wealth of analysis and region-specific policy prescriptions. Instead, Crotty blames most of the productivity and stagnation problems on trade and finance policy of DCs. This leads to recommendations that the United States import Latin American calves for fattening. One need only check the charges at the Fleming Key quarantine station to gauge that recommendation. The same problem holds for export of surplus calves from India to Japan and the Middle East which would, incidentally, reduce the international prices of feedgrains since these countries would then import more grain to fatten these calves. Using LDC cattle exports to bargain with OPEC on oil prices is also recommended, as is forcing the EEC to dismantle its Common Agricultural Policy to help potential calf exporters from Africa and India.

Despite these criticisms, most of the book represents a skillful blend of Crotty's extensive international experience, considerable analytical skills, and deep understanding of the essential problems of cattle production in LDCs. The result is an innovative set of models which allow the author to condense the complex systems and to come up with generally practical conclusions that illustrate clearly why LDC cattle production has not progressed and why so many cattle investment schemes have fared poorly.

The book represents a valuable addition to our knowledge of cattle economics, is a must for any researcher concerned with animal production in LDCs, and should be standard reference for international agencies contemplating entry into the complex world of man and his cattle.

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Fennell, Rosemary. *The Common Agricultural Policy of the European Community*. Montclair, N.J.: Allenheld, Osmun & Co., 1979, xi + 243 pp., price unknown.

It is surprising but true that no recent book or publication exists in English that explains in simple terms the apparent complexities of the Common Agricultural Policy (CAP). Rosemary Fennell has filled this gap with a useful book for the many whose professional work brings them into occasional contact with the CAP. The book is concise, easy to read, and well-organized; it contains about as much factual information in 230 pages as one can reasonably expect. Separate chapters deal with European Community (EC) institutions, the legislative process, the financial arrangements, and that arcane topic, "green money." Market support mechanisms are described in three chapters—covering field crops, livestock, and horticultural products; and two particularly valuable chapters outline structural and social policy measures related to agriculture. A brief chapter on "enlargement" of the Community—the accession of Greece, Spain and Portugal—rounds out the book, though because the manuscript was completed before the end of the Greek negotiations for membership, this last chapter appears somewhat dated.

The author succeeds admirably in her limited objective of "explaining the rudiments of the policy" to act as "a base on which greater and more detailed knowledge can be built." The book does not set out to analyze either the policy in general or particular market instruments, and even avoids any reference to places where such analyses can be found. It is content to detail the "institutional and administrative organization" of the policy, leaving interpretation to the reader.

There are places, however, when even in a basically descriptive work some analysis can be useful, if only to distinguish the important from the trivial. For example, the listing of policy instruments for the various commodities in chapters 8 to 10 gives little information on which mechanisms actually are effective in determining prices in product markets. Although the author includes some useful diagrams showing the relationships among the various institutional prices set under the principal commodity policies, some simple charts showing how market prices have varied in relation to these administered price levels would have given the reader a better feel for the important aspects of the policy.

On the relatively few occasions when analytical statements creep into the text, they sit uncomfortably amid the descriptive passages. We learn, for instance, that "insulating Community farmers from world market influences" and providing them with "minimum levels of support achieved through the underpinning of prices" should lead to "an intensification of the comparative advantage of different regions" (p. 104). This smacks of the confusion that has bedeviled the CAP from its inception. While the removal of national protection would have had the effect of "rationalizing" production and also would have led to common prices, the setting of common prices at levels which support high-cost production and the buying-up of surpluses effectively prevents such adjustment. Though one could argue that this system is still "better" than if each country protected its own farmers, even that limited contention is of doubtful validity in a system where the national incentives to seek higher common support prices are so strong.

If such analytical statements creep in reluctantly and with limited impact, one has the impression that statements of opinion, equally rare, are struggling for inclusion but being carefully repressed by the author. They surface particularly in the chapter on institutions. "Little attention," we learn on page 29, is paid to the Economic and Social Committee by the Council of Ministers on matters relating to the CAP. "This is regrettable," sighs the author, "as its views are often well thought out." Opinions are free, and though this reviewer finds it difficult to reconcile this particular view with a recollection of the ESC as the author of some of the most wooly and equivocal documents in Brussels, such "asides" do not intrude. Indeed, a little more commentary might have helped to leaven an otherwise humorless topic.

One caution should be given to the reader. It is a conceit of the Brussels administration that the CAP is a straightforward, if elaborate, set of regulations spanning the Community and replacing national policy instruments. Fennell tends to perpetuate this myth. In fact, as CAP-watchers know, the "common" policy is riddled with national derogations, is unevenly applied among countries, and lives uncomfortably with national agricultural policies which in total absorb more government funds than the CAP itself. For the author to have attempted to describe this interaction with national policies—or indeed the way CAP regulations are implemented in individual countries—would have increased massively the size of the book. But again, some reference to these complexities would have helped the reader to put in perspective the "rudiments" of the CAP as given in the book.

These comments should not be taken as detracting from the clear merits of the book as an introduction to the CAP and as a convenient work of reference for the bookshelf. Nevertheless, as I am sure the author would agree, there is still ample scope for other books to explain, analyze, and interpret the CAP to the profession. The European Community is a dominant power in world agriculture: a better understanding of its operations can do nothing but good.

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Franke, Richard W., and Barbara H. Chasin. ***Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel.*** **Montclair, N.J.: Allanheld, Osmun & Co., Universe Books, 1980, xvi + 267 pp., price unknown.**

Seeds of Famine is a study of the political economy of historical and contemporary development in the Sahelian zone of West Africa. Franke is an anthropologist and Chasin, a sociologist. Their interest in the topic began in 1974 toward the end of a long and disastrous drought in the Sahel which began in 1968 and led to widespread hunger and famine. The book's audience is expected to be students, the general public, and scholars interested in the Sahel and the linkages between food production and the environment. Professional economists looking for analytical insights into the development process in the Sahel will be disappointed.

Franke and Chasin's (FC) thesis is that the deprivation witnessed in the 1968–74 Sahelian drought resulted from ecological destruction attributed primarily to the policies of the French colonial administration from the middle of the seventeenth century until 1960, when the countries gained their independence. FC's radical approach to understanding the causes of the drought rejects "single-variable" explanations, such as weather changes, desertification, overgrazing, mismanagement, population growth, and the "tragedy of the commons." Rather, the colonial system is indicted for destroying the beneficial interregional trade patterns which had been in existence between North Africa and the West African humid tropics since the days of the Ghana empire (500–1200 A.D.). The promotion of peanut cultivation by France in the eighteenth century led to growth in the area of cropland at the expense of pastures for animal grazing. The tax system established by the French also encouraged commercial cropping in order to earn the money necessary to pay the taxes. Degradation of soil resulted from the reduced fallow periods and forest areas and the demands peanuts placed on soil nutrients. Herders were forced to move animals further north toward the Sahara, thus breaking down complementary exchange relationships between farmers and herders in the Sahel.

Expansion of wells and watering points for herds after 1940 further exacerbated the problem by concentrating animals around them. Vaccination, animal health programs, and growing southern livestock markets led to a large growth in livestock numbers. "The peanut and the profit system were the real 'overgrazers'—not the nomads" (p. 99). These processes caused extensive ecological damage, and when the 1968–74 drought came, the frail ecology could not support the increased human and animal populations.

A feature of this book that detracts from its scholarly value is that many sources are newspaper reports and anecdotal material. Also, the tone is excessively emotional. The authors' analyses of the pre- and post-colonial eras are full of inconsistencies. These are epitomized by their statement about the effect on nomads of the introduction of ocean trade by the French: "The loss of the caravans was a severe blow to the nomads who . . . sometimes raided these caravans" (p. 67).

FC deplore the post-colonial dependency of Sahelian countries on the West for foreign capital investment and export markets, both of which they claim ensure the Sahel will become more vulnerable to future droughts. In a region where capital is scarce relative to land and labor, one wonders from where the Sahel could find the capital to invest in increased fertilizer use, which FC maintain is one of the major avenues for alleviating the soil degradation caused by peanuts. Many such contradictions permeate the book.

In rejecting "tragedy of the commons" explanations of the famine, FC imply there was little farmer/herder competition prior to the advent of the "capitalist ethic." No strong evidence for this is cited. Their arguments are made even less tenable by the statement (p. 122): "It was not simply herders and their lust for greater numbers of animals, but the pressures of the profit system that led to the overgrazing. . . ." The authors imply no profit motive existed before the colonial era. This is obviously not true as is clear from FC's own earlier descriptions of trade and commerce along the old caravan routes.

FC contend the large-scale projects being funded by the international community under the Sahel Development Program (SDP) in response to the 1968–74 drought are doomed to repeat past errors. They will ensure continuation of dependency relations and exacerbate the conflicts between cash cropping, food production, and herder interests. FC see conspiracies and capitalist plots behind many of the SDP projects. According to them, aid is being used to offset unequal trade relations, and the net result is that the populations are made no better off.

FC's solution to the development dilemma in the Sahel is for development to proceed from the bottom up via small projects instead of from the top down, as in the large-scale SDP projects. The mechanism for this is to be the formation of farmer/herder collectives based on the model of the Federation of Soninke Peasants in Senegal. This small non-SDP project seems to be the only project site the authors visited in their five months in West Africa.

The authors conclude the book by essentially advocating revolution by the citizens of the Sahel. Applauding the recent coups in Mauritania and Mali, they urge the formation of farmers' and herders' political and economic associations. "These nascent organizations . . . must eventually control the political and economic systems of entire Sahelian countries" (p. 237). The reader could be excused for being skeptical about this *non sequitur* for avoiding the adverse effects of the next drought.

The *coup d'états* instead could deliver the *coup de grâce* to the Sahel and its people!

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Frankena, Mark W., and David T. Scheffman. ***Economic Analysis of Provincial Land Use Policies in Ontario.*** **Ontario Economic Council Research Study No. 18. Toronto: University of Toronto Press, 1980, viii + 171 pp., $7.50.**

This study is an economic analysis of the government's role in municipal and regional land planning in Ontario. The great merit of the monograph is that it brings together much relevant material. It provides a thorough survey of government intervention in the land market and a description of the legislation during the last two decades. Because Ontario statistics on land use are inadequate, the review of case studies dealing with the conversion of agricultural land to nonagricultural uses is most welcome. For the noneconomist, a valuable theoretical chapter outlines under what circumstances the land market fails to allocate efficiently.

Despite these merits, the monograph is disappointing in the analysis, and particularly so in the prescriptions. In their analysis of the conversion of agricultural land to other uses and its significance for food production, their data are suspect. Chapter 5 asserts that in the aggregate, the rate of conversion of land to built-up urban uses is low in relation to the rate of productivity increase in agriculture, the stock of agricultural land, and the decrease in the acreage of census farms. The productivity figures used are gross, including inputs produced on land outside Ontario, such as feed grains, calves, and heifers. The productivity increase of the major crops, including hay, in Ontario is considerably lower, roughly half the overall gross productivity increase. Moreover, closer inspection reveals that the rate of productivity increase is decreasing drastically. Since 1966, population growth in Ontario has exceeded the growth rate of total gross agricultural output.

The authors estimate that during the past decade about 1% of the good agricultural land was converted to built-up urban use. This is primarily based on a study of twenty-four urban areas with a population of 25,000 or over in 1971. What happened outside these areas in the form of losses to transportation and power corridors, power sites, water reservoirs, waste disposal sites, and new towns is ignored entirely. We are left in the dark, failing the availability of data, as to the cause and ultimate destination of much of the decrease in the acreage of census farms. Land becoming submarginal for agriculture is one explanation, illustrated by the tobacco example on pages 67 and 68, in which the authors incorrectly presume that the unit cost of tobacco production on lower quality land is necessarily higher than on prime land. Although the submarginality cause is plausible, particularly for unimproved land, it is not so obvious that the large decrease in improved land in the late sixties is caused mainly by this.

It seems that the authors have highly overestimated agricultural productivity growth on Ontario farmland, and underestimated the conversion of agricultural land to economically irreversible uses other than built-up uses in urban centres and rural nonfarm residential development. Although not explicitly stated, the message one gets is that much of the prevailing concern is unjustified. To call some of the discussion alarmist and cataclysmic rhetoric does little to bring economists, planners, and policy makers closer, which is what the authors hoped to accomplish.

The difficulties in performing the prescribed cost-benefit analyses are not elaborated. For example, how would the authors measure the benefits from rural nonfarm housing to find out whether or not a restraint policy should be implemented? Is it the maximum price potential residents are willing to pay to live in the rural area or the minimum amount they are willing to receive if they are excluded from that area? Moreover, how are they to be identified? Despite the absence of much of the necessary information and background, the authors insist that adoption of provincial guidelines or controls must be preceded by a cost-benefit analysis, since they feel that the burden of proof should be on the government. Because of these difficulties, many of those computations would be highly suspect. No cost-benefit analysis or other evidence is presented in support of the authors' doubts about the justification of many forms of government intervention in the land market, as the introduction promises.

The authors consider the maximization of national welfare as the exclusive objective of conservation policies. Because long time horizons, massive uncertainty, and economic irreversibility are involved, a better objective is to avoid future food calamities, even if their probability is small. It is impossible to quantify the benefits of such policies exactly, but their order of magnitude can be established. The cost of such an insurance policy is the decrease in national welfare, under the most probable conditions, imposed by the conservation policy. This decrease does not necessarily invalidate the policy as the authors conclude, but must be compared with its benefits.

Willem van Vuuren
University of Guelph

Friedmann, John, and Clyde Weaver. ***Territory and Function: The Evolution of Regional Planning.*** **Berkeley: University of California Press, 1980, 240 pp., $6.95.**

The authors present an historical perspective of regional planning by emphasizing particular indi-

viduals, schools of thought, governmental programs, and spillovers from other disciplines that they feel are noteworthy to the development of this field. Their basic thesis is that clarification of the "state of the art" in the evolution of regional planning doctrine is necessary to answer critics as well as to complement efforts involved in reexamination and reconstruction of planning philosophy. This is clearly indicated by such statements as "this . . . will help to throw regional planning doctrine into relief by revealing its origins, the options that were rejected, . . . alternative formulations that were neglected, and the new forms of doctrine . . . beginning to emerge" (p. 2).

Early in the book, Friedmann and Weaver point out two forces, territorial and functional, of social integration that they believe systematically surface in their reconstruction of the history of regional planning. The former relates to common bonds and the latter force to self-interest. The title of the book originates from these two components and this writer feels that such a label is misleading. First, the subtitle is more relevant to content than the main title, and second, it is not explicitly clear where each force is applicable and in what context during the various discussions.

The book is divided into three parts designated as regionalism in America, a spatial framework for capitalist planning, and the crisis in development, respectively. The first section contains some of the important social and intellectual changes that are interpreted as contributing to regionalism in our country. Discussion centers upon such events as urban industrialization, Theodore Roosevelt's conservation movement, impact of institutional economics, and the effects of governmental economic and social programs. The second section emphasizes theories of unequal and polarized development and policies to deal with residual areas. The final portion of the book explores the ramifications of the transnational movement upon regional development doctrine. The authors argue that as a result of transnational ideology reflecting functional power, there is a need to change regional doctrine to encompass more of the territorial (or common bonds) aspects of social integration. To accomplish this, Friedmann and Weaver lend support to a "basic needs" approach (termed "agropolitan").

The first two sections of the book are germane to the basic thesis of the book. The discussion generally centers upon the emergence of regional planning doctrine. It is the latter section which destroys the earlier success. The impression is given to this writer that the last part is written to resurrect the senior author's earlier original formulation of the "agropolitan" concept. The last section abruptly turns to regional development in developing countries. This sharp twist seems unrelated to previous material.

The authors should have enlarged the first two sections with additional focus upon current short-run influences associated with research and political trends that have a strong likelihood of affecting planning doctrine. The authors should have emphasized the analytical approach centering upon the importance of remote sensing and computer graphic techniques to their field. The influence of academic disciplines, i.e., environmental and community economics, upon regional planning is overlooked as well as the impact of the "less governmental intervention" or libertarian movement on this field.

This writer feels that the authors missed an opportunity to clarify the role of the engineer in the field of regional planning. The only time that the engineer is introduced into the book is in one short sentence where "the one . . . example of regional planning in practice, the TVA, was largely the handiwork of engineers . . ." (p. 92). Friedmann and Weaver should have described the complementing roles of the two professions as well as differences.

The authors obviously have an in-depth understanding of the literature influencing regional planning as illustrated by the many references contained throughout the book. In fact, Friedmann and Weaver introduce such a large number of footnotes at the end of each chapter that this writer became weary of turning pages in response to each note. Much of the information contained in the explanatory notes could readily be incorporated into the main text.

The advertising statements on the back cover designate this work as a landmark in the study of regional planning. It should be labeled a landmark in the sense that the authors should rethink, reorganize, and expand the existing effort to accomplish their original objective. The book, in its present form, falls far short of its intent.

Bruce E. Lindsay
University of New Hampshire

Halcrow, Harold G. ***Economics of Agriculture.*** **New York: McGraw-Hill Book Co., 1980, xiv, 383 pp., price unknown.**

The past few years have seen a spate of textbooks on the economics of agriculture for undergraduate students. Halcrow's contribution is slanted toward readers with little or no previous experience or knowledge in either economics or agriculture. It is intended as an introduction to more advanced courses in agricultural economics and to present an understanding of the major economic problems of agriculture to students in the physical and biological sciences, some of whom may have no idea of what agriculture is about.

The organization of the book appeals to this reviewer's biases and prejudices. There are ten fairly self-contained chapters. Each chapter starts off with a statement notifying the reader what the chapter contains. The exposition follows with clear,

simple definitions, in appropriate places, of rules, terms, and laws required for discussion of the subject. Discussions are well-illustrated with appropriate figures and tables, presented in a clear and straightforward manner. At the conclusion of each chapter is a concise summary of the material presented and a list of the important terms and concepts included in the discussion. This last serves a useful purpose for readers who might otherwise fail to recognize concepts as they read. It should save a lot of underlining in red pencil. Each chapter ends with a short statement about what is coming next and a list of questions and answers that should aid the student in reviewing the chapter.

The central economic problems of agriculture are listed and discussed early in the book. These are followed by a brief history of mankind's population growth since prehistoric times and its implications for the future of agriculture. Then follows a discussion of production functions and costs. This is pretty much limited to a discussion of single-variable inputs. Factor-factor, product-product, complementarity, and supplementarity are given light treatment consisting primarily of definitions and a brief discussion. Demand and supply and their elasticities are given rather thorough treatment. There follows a discussion of the competitive structure of agribusiness and production and marketing strategies of agribusiness firms dealing with meat and poultry, cereals, dairy, sugars, oils, and processed fruits and vegetables. Most of this discussion is descriptive. The chapter on farm income problems and programs discusses farm price and income problems and then describes past programs dealing with these problems from a historical and political perspective as well as in simple analytical terms. The final chapter deals with the historical development of international trade in farm products and its importance to American, as well as international, agriculture. Included is a brief discussion of the European Common Market and the Kennedy and Tokyo rounds to reduce international trade barriers. The book concludes with an excellent glossary of definitions of terms, rules, and laws used in the text.

The objectives of the text as stated in the preface are to begin with basic economic and agricultural concepts, develop a broad view of the central economic problems of agriculture and apply the concepts and principles to problem solving. It is in the final objective that delivery is not made. The author has done an excellent job presenting the central economic problems of agriculture and the basic concepts needed to solve those problems. But he does little to further a student's understanding of how the concepts discussed can be applied to problems of decision making by a farm firm or to formulation and implementation of public policy with regard to agriculture in the macro sense. Those who believe in use of concepts for analysis and decision making will miss the application of the concepts to such uses in the text. However, one text cannot be everything to all people. When it is realized that this text requires no previous knowledge of either economics or agriculture, one cannot expect a product covering all aspects of agricultural economics. If we place lack of development of analytical economic ability on the part of the student aside, this is an excellent text for students of limited background. In fact, there is no need to limit the text to students: it could be read profitably by any high school graduate who is interested in gaining some background about and insight into the economic problems of American and international agriculture.

Anthony P. Stemberger
Pennsylvania State University

Hicks, John. ***Causality in Economics.*** **New York: Basic Books, 1980, 124 pp., $8.95.**

This little book contains thoughts on methodology, the history of science and causality, and some words of caution about the use of probability in economics. Those thoughts and words come from the mind and pen of one of the more honored economists of the twentieth century. Therefore, they must be assumed to have some potential impact. I would like to take up some issues of disagreement in what must be a modest manner. Hopefully the theme and outline of Hicks' book may be filtered out of those comments.

Hicks says that economics is "on the edge of the sciences," and the central argument by which we are placed in those far suburbs is that true science develops propositions that are timeless. Their refutation (or lack of it) does not depend upon a time frame. In later chapters we are given Newtonian mechanics as an example of a set of scientific propositions that lasted two centuries before requiring modification for at least some sets of now observable data. Moreover, we are given a discussion of Adam Smith's propositions that wealth is concentrated near water transport. The point is that changes in technology (and technology is outside economic theory) may lead to a change in the truth-value of Smith's locational theory.

Borrowing from Hicks' own taxonomy of causation (chap. 2) and pondering his examples, we might draw the lesson that physics (at least, Newtonian mechanics) contains a great number of strongly causal relationships. In other words, *ceteris paribus* is not so crucial as it is in economics. This would enable us to interpret Hicks' use of the phrase "out of time" to mean that "time" is a shorthand for critical environment—all those things that must be held constant to make a meaningful causal statement. Certainly, one would not quarrel with the importance of the bundle of *ceteris paribus* for economics. We often yearn for strong causality, or at least costless experiments, which would provide dramatic evidence, for example, regarding the

proposition that doubling the money supply will, *ceteris paribus,* double the price level. To me, all this only says that economics is a difficult subject, differing in degree but not in purpose from other sciences. I get the impression that Hicks is saying more than this.

Alternatively, if we adopt the adage that "there is nothing new under the sun" for physical phenomena, one would find a significant point of departure. Economics is a social science, and societies evolve. However, as I understand modern notions of the universe, astronomers would feel no more comfortable with the adage than would biologists or economists.

Again, if one measures critical environmental constancy, or the lack of it, against real time, I would be prepared to believe that new phenomena may be more abundant in economics—a matter of degree. However, one must not give points away so quickly. The effects on scarcity of Diocletian price ceilings on food must have been much the same as more recent ones on natural gas. Similarly, coin clipping by Nero would have had some of the same effects as the Federal Reserve Bank buying bonds from the U.S. Treasury to finance the purchase of current goods and services.

Indeed, one wonders whether the crucial difference between economics and the "hard sciences" is because of so much change in the critical environment or whether it is because of the lack of "experimental data" due to little (or only slow) change.

Two of the crucial "experiments" of this century for economists in the industrial world of private ownership of capital have been the Great Depression, to which Keynes responded, and the inflation (together with unemployment) of the past ten years. Certainly there have been other "experiments" with inflation and recession in many countries, but the mass of theorizing and testing caused by the two events mentioned must dwarf the literature inspired by other events. It is my impression that economics as a science has responded to these new sets of data by revising its theories to account for the new data without countering the old. This is the response any science makes to new data.

The question of whether economics differs as a science is not at issue. The issue is whether the differences are so crucial that economics either does not qualify as a science or qualifies only as a poor neighbor. Given the recent decision by the current administration to let the entire National Science Foundation budget cut fall on economics, this rather nebulous and ancient issue evidently can be a crucial one. There may be unscientific economists, but economics is a study of mankind which seeks to develop hypotheses about human behavior, hypotheses that have empirical content in the sense that they are capable of being refuted. Therefore, economics is a science, and those who saw fit to include the discipline for Nobel awards showed good taste and common sense. Hicks never actually calls economics "unscientific" in his book, but he comes a bit too close to suit this reviewer.

Dudley Wallace
Duke University

Judge, George G., William E. Griffiths, R. Carter Hill, and Tsoung-Chao Lee. *The Theory and Practice of Econometrics.* New York: John Wiley & Sons, 1980, xxvii + 793 pp., $26.95.

This book covers most of the standard topics discussed in graduate econometrics courses and texts, with the notable exception of simultaneous equation models, a reasonable omission because the book is already long and because simultaneous equation models are well covered elsewhere. (Simultaneous equation models have been the subject of less recent work than many other topics covered here.)

The book is impressive as scholarship. There is a long list of topics for which the book provides the best textbook treatment currently available. For example, the book contains forty pages on heteroskedasticity, a topic often slighted in other texts, and it covers almost everything in the econometric literature on this topic. Other topics of which coverage is complete include autocorrelation, pooling of cross-section and time-series data, random coefficients models, unobservables, distributed lag models, and nonlinear models and related computational methods.

As would be expected, the book reflects the research interest of its authors. Thus there is an extensive discussion of pretest and shrinkage estimators (ridge regression and Stein-rule types), some of it with reference to multicollinearity, some not. There is also an extensive discussion of the related problem of selection of regressors. The discussion of the linear model under ideal conditions is cast in a decision-theoretic framework. My personal opinion that this is interesting in theory but useless in practice is obviously not shared by the authors.

It is typical in reviews of this type to search for minor flaws, to avoid the appearance of unquestioning approval, but it is difficult here because there is not much to criticize. The treatment of the linear model under ideal conditions is neither extensive nor clear, but the topic can be found easily in other texts. As noted above, simultaneous equation models are omitted entirely. One might also argue that time-series methods in general are not adequately covered.

In the preface, the authors state that the book is intended as a text and as a handbook or reference book for students or others. As a handbook or reference book, it has no serious competition—on the topics it covers, it is by far the best available. As a text, I expect it will be widely adopted in

courses for which two or more texts are used. As a sole text, it would be overwhelming for any but the most advanced, topics, courses. Precisely because the coverage is so encyclopedic, there is a tendency for standard econometric topics to become lost. (For example, a student might learn twenty ways to handle autocorrelation but miss the point that in practice virtually everyone uses the Durbin-Watson test and Cochrane-Orcutt transformation.)

While texts achieve varying degrees of financial success and critical acclaim, only the best constitute a service to the profession. This book is in that class.

Peter Schmidt
Michigan State University

Kada, Ryohei. *Part-Time Family Farming: Off-Farm Employment and Farm Adjustments in the United States and Japan.* Tokyo, Japan: Center for Academic Publications, 1980 (ISBS, Inc., Forest Grove, Ore., exclusive distributor), xv + 264 pp., $26.00.

This book reports on a comparative socioeconomic study of part-time farming in two samples of households, one from Wisconsin and one from Shiga Prefecture, Japan. The main hypothesis is that decisions of a farm family for taking off-farm employment are influenced by internal factors—stage in family life cycle, aspirations and goals of the family, quantity and quality of resource endowments—and external factors—off-farm employment opportunities, availability of additional farmland, and farm technology. The main method of analysis is descriptive within a typological framework. There is minimal application of economic theory to the labor supply decisions of farm household members and of econometrics. Thus, there is no serious statistical testing of a model of off-farm work participation or of supply of hours of off-farm work by farm household members.

Chapters 1–3 of the book provide an introduction to the study, a review of some of the international statistics and literature on part-time farming, and a comparison of structural change in U.S. and Japanese agriculture during the twentieth century. The comparison relies heavily upon the research by Hayami and Ruttan. Chapters 4–7 present the major findings. In this study a part-time farm family is defined as a farm household where one or more members engaged in off-farm work, including self-employment, for thirty days or more per year. The data for the analysis were obtained from interviews of 193 Wisconsin farm households and 245 farm households of Shiga Prefecture, Japan. Neither sample represents a probability sample of the respective geographic unit, so generalization would be difficult even if models were fitted econometrically.

In chapter 4, the topology of part-time farm families, which is used for classifying the farm households in later descriptive analyses, is presented. The classification considers the career pattern of the farm operator and the historical mobility of the family (for Wisconsin) or structure of the farm family (for Japan). The sample mean values of socioeconomic characteristics, including farm type, gross farm sales, net farm income, off-farm income, number of household members, number working household members, are presented for each of the typological classes.

Chapter 5 presents data mainly on subjective responses by typology class on motivation for off-farm work, kinds of on-farm and off-farm adjustments to facilitate dual jobholding, and conflict versus complementarity of dual jobholding. The chapter also presents data on who in the household participates in dual jobholding (i.e., who works greater than or equal to thirty days per year at farm and off-farm work). The reported frequency of dual jobholding is 62% for husbands and 16% for wives in Wisconsin sample farm households and 45% for husbands and 13% percent for wives in Shiga sample farm households.

Chapter 6 presents a description of time allocation of household members by farm size (acres) and farm type. It also shows the simple correlation of farm versus off-farm work of different household members. In chapter 7, the author attempts to give a life-cycle perspective to part-time farming. Households are classified by family stage, e.g., preschool, school age, etc. The main difference between U.S. and Japanese stages are due to the nuclear U.S. family system and the Japanese stem family, which is perpetual with family composition changing over time. Tables are presented showing labor input, family size, net farm income, off-farm characteristics, and type and size of farm by these family stages. Working time allocation seems to differ. In Wisconsin sample families, hours of farm work and off-farm work move inversely over family stages, but in Shiga households, they move together.

The author should be commended for his attempt to add to our knowledge about part-time farming. Unfortunately, the results do not go beyond being suggestive.

Wallace E. Huffman
Yale University and Iowa State University

Reference

Hayami, Y., and V. Ruttan. *Agricultural Development: An International Perspective.* Baltimore, Md.: Johns Hopkins University Press, 1976.

Pearse, Andrew. *Seeds of Plenty, Seeds of Want: Social and Economic Implications of the Green Revolution,* New York: Clarendon Press, Oxford University Press, 1980, xi + 262 pp., $22.50.

Pearse and I have been green revolution watchers for over a decade. His views are summarized in the book under review; mine in a recent article (Dalrymple). Our perceptions generally differ quite sharply. I probably would not be his first choice as a reviewer.

The book is an overview of an earlier study known as Global Two, carried out between 1970 and 1974 by the United Nations Research Institute for Social Development (UNRISD). Pearse was project manager; he is currently Co-Director of the Participation Program for UNRISD.

Individual country studies were done by scholars representing a wide range of professions, particularly social science. According to Pearse:

> They sought to illuminate and explain the emergent situations at different levels and in different ways.
>
> Each used his or her own methods of research. No standardized instruments were insisted upon but it was made clear that field studies were required. . . .
>
> Most of the studies that resulted attempted to look at the introduction of the new technology in the context of one or several primary rural settlements. . . . (p. 2)

Altogether, sixteen bulletins were published and at least fourteen other manuscripts were prepared and/or issued between 1971 and 1977. A *Summary of Conclusions* was released in 1974, and a draft "Overview Report" was prepared in 1976 but not published. It was decided that "a more analytical and interpretative summary of the conclusions" was needed (p. viii).

The individual bulletins were a hodge-podge in terms of subject matter, approach, and presentation. They did share a preoccupation with the negative aspects of the green revolution and almost totally neglected its broader social contributions: (*a*) direct benefits to consumers beyond the producing village and (*b*) the indirect benefits such as the stimulus provided to multiple cropping and the multiplier effects on the economy. While it was assumed that the purpose of the technological changes was to provide freedom from food dependence on other nations and freedom from hunger (p. 3), very little attention was given these key issues.

The present book was largely shaped by this background. Had it been issued in the mid-1970s, it would have fitted in comfortably with some of the unbalanced literature of the time—which was much more concerned with the seeds-of-want aspect than with the seeds-of-plenty dimension.

But the book was not published until late 1980, and then it was not updated. A flood of literature has appeared on the green revolution since the mid-1970s, but essentially none of it is noted or incorporated in the book. The green revolution matured during this period and so did much of the writing about it. Pearse's account, therefore, is antiquated.

Well, then, how does the book do as a product of the early 1970s? Not very well. Virtually everything that Pearse says about the green revolution has been said before, and better, both by himself (in *Summary of Conclusions*) and by others. Pearse's current text meanders and is unexpectedly tedious.

This is not to say, however, that some new material has not been added. Yet nearly all of it concerns the problems of technology as related to agrarian structure, land reform or tenancy, and the evils of market-oriented capitalist agriculture. Indeed, at points it seemed that I was reading a tract on "Tenancy and Technology." The green revolution often appeared more a pretext than the major subject.

Near the end, Pearse does turn to a more useful and topical, though hardly pathbreaking, discussion of appropriate technology (chap. 12). There he advocates what has in reality emerged over the past decade: the expanded development of technologies more suitable for the less well-endowed farmers.

Pearse concludes with a chapter in which he eulogizes peasant-based strategies followed in China, Taiwan, and Japan. All three, of course, had rather autocratic land reforms ("historic events larger than the agricultural sector," p. 243).

> Thus, the dynamic process of a fully capitalist development in the sector has been eliminated or kept under control, and the marginalization and "delanding" of the peasant majorities, with all its social pathology, political instability, and individual trauma, has been avoided. (p. 243)

Whether these additional insights were worth the long wait is highly questionable. More "interpretative" they are; more "analytical" they are not.

Despite my misgivings about the book as an assessment of the green revolution, it probably will sell relatively well. It has a promising pedigree, an attractive appearance, an enticing title, and a prestigious publisher. Unfortunately, the contents are not up to, nor even true to, the package. But few purchasers will be immediately aware of this.

It is a pity that the seeds of such a promising project bore such tardy, meagre, and twisted fruit.

Dana G. Dalrymple
USDA and USAID

Reference

Dalrymple, Dana G. "The Adoption of High-Yielding Grain Varieties in Developing Nations." *Agr. Hist.* 53(1979):704–26.

Sanderson, Fred H., and Shyamal Roy. *Food Trends and Prospects in India*. Washington, D.C.: The Brookings Institution, 1979, xiii + 162 pp., price unknown.

Ray, Susanta K., Ralph W. Cummings, Jr., and Robert W. Herdt. *Policy Planning for Agricultural Development*. New Delhi, India: Tata McGraw-Hill Publishing Co., 1979, xiv + 237 pp., price unknown.

These two books provide carefully researched analytical accounts of the development issues of Indian agriculture, of interest not only to those involved with India's economic development but to all those who are concerned with policy research and planning in the developing countries of the third world. Because it accounts for one-third of the population of the third world, the prospects of policies and programs for agricultural development in India are of international concern.

An excellent overview of the study by Sanderson and Roy was provided in chapter 1. An assessment of the trends in food grain production and population growth in the past quarter century has been described as the "food-population crunch," which is the real problem to be tackled effectively by appropriate policies and action programs in India. However, Sanderson and Roy devote little attention to the population problem as such or to the interlinkages of agricultural development and demographic factors. Instead, they concentrate on presenting an analysis of the long-term trends in food grain production and examine the contribution of input factors affecting production of rice, wheat, coarse grains, all cereals, and pulses. However, in discussing economic factors affecting the trends in food grains in chapter 4, the authors have not provided convincing analysis to support their conclusion that "with a few exceptions, fluctuations in real prices and returns per hectare, and fluctuations in the grain-fertilizer price ratios, did not exert a significant influence on fertilizer use or on weather-adjusted yields." Unfortunately, this kind of empiricism could lead to wrong policy prescriptions and perpetuate the market imperfections. A good discussion of the institutional factors affecting food trends is given in chapter 5.

In the second part of the book, the authors attempt to project the probable demand for food in 1990 and 2000 and examine whether it can be met from domestic production. Even if one has any differences with the authors' calculations of returns from irrigation and fertilizer, one can reasonably agree that these two are key factors for achieving additional increases in yields of food grains in India.

The last chapter of the book is devoted to policy implications. The authors have correctly cautioned the policy makers that they should be careful in evaluating the alternatives. However, they also could have emphasized that monitoring and continuous evaluation of the impact of the policy decisions in relation to the objectives is also needed. The value of this book by Fred Sanderson and Shyamal Roy to students of agricultural economics would have been enhanced if they had provided an index and a bibliography to the literature cited.

The book on *Policy Planning for Agricultural Development* by Ray, Cummings, and Herdt provides an excellent historical perspective and analysis of the agricultural development in India. In part one of the book, the authors discuss the agricultural stagnation up to the end of British rule and development under planning after independence (1951–75). After this, the authors present the framework for agricultural development in India in part two of the book, which is divided into three chapters (4–6) dealing with the role of agriculture in stimulating Indian economic growth, policy strategies, and alternative growth scenarios that might result. The planning strategy for 1978–83 described by the authors in chapter 4 is unfortunately now of academic interest only, because of the dramatic political developments that took place in 1980. With the comeback of Indira Gandhi to power, the Draft Plan for 1978–83 has been abandoned and the new Planning Commission is preparing a Sixth Five-Year Plan for 1980–85. However, the policy strategy presented by the authors in chapter 5 will be relevant even under the new Gandhi regime.

From the population policy point of view, it is of interest to note that Ray, Cummings, and Herdt think that "a higher agricultural growth rate should also increase the possibility of accelerating family planning." This is based on the implicit assumption that higher agricultural production will improve nutrition, particularly for pregnant and nursing mothers and young children, and this will increase life expectancy by lowering chances of death during the first ten to fiteen years. However, this is a simplified and stylized approach to an important and complex demographic problem of developing countries like India. The authors could perhaps have drawn the attention of the readers of their book, in this context, to the literature dealing with the "new home economics," as Nerlove called it.

Part Three of the book provides an excellent analytical account of policy issues dealing with research and education; production input requirements; economic infrastructure, marketing, and rural centering; price policy; and equitable development.

Both of these books are timely and useful to policy makers and researchers, because India is entering a new phase of economic development and the issues require new analytical insights. These two books can stimulate the necessary thinking in the right directions.[1]

M. T. R. Sarma
International Labor Organization

[1] The views expressed here are entirely in the personal capacity of the reviewer and do not represent in any way the International Labor Organization, in which the author is currently employed.

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American Journal of Agricultural Economics

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Articles

Common Property Externalities: Isolation, Assurance, and Resource Depletion in a Traditional Grazing Context

Carlisle Ford Runge

Institutional alternatives to common property externalities are wider than argued by private exclusive property rights advocates. The "tragedy of the commons" is not a prisoners' dilemma, characterized by the strict dominance of individual strategies. The nonseparable common property externality is an "assurance problem." The assurance problem provides striking perspectives in analytical and policy terms. It redefines the problem of the commons as one of decision making under uncertainty. Institutional rules innovated by the group to reduce uncertainty and coordinate expectations can solve the problem of overexploitation. Rules come in many forms, and private property is only one.

Key words: common property, institutional rules, nonseparabilities, prisoners' dilemma.

Externalities lead to nonoptimal market allocations. The literature is filled with examples of "market failure" arising from the divergence of private from social cost (Bator, Coase, and Meade). The "tragedy of the commons" arising from grazing too many cattle on a given area of land has been widely noted as an important representative case of externality. The private benefit of grazing an additional head of cattle on a common range exceeds the private cost, because part of the cost is incurred by the entire group engaged in grazing. As a result, individuals have an incentive to "free-ride" and resource overexploitation results (G. Hardin).

The example of a common property externality is only one of a large number of structurally similar problems. These include overexploitation of common fishing grounds, extraction of oil and natural gas from a common underground reservoir, deforestation of common lands for fuelwood, depleting underground water sources, and some pollution problems of common air and water resources (Dasgupta and Heal, pp. 73–78).

Economists have struggled to find appropriate analytic and technical tools to model these important problems. One is the theory of games (Von Neuman and Morgenstern, Luce and Raiffa). It has been widely and erroneously assumed that common property externalities arise for reasons associated with the famous "prisoners' dilemma" game. This paper will demonstrate (*a*) that such an assumption is a false interpretation of the problem and (*b*) a correct game-theoretic formulation of common property externalities. This formulation is known as an assurance problem (Sen). Assurance problems have interesting implications for institutional rules designed to halt environmental degradation. The discussion will focus on problems of overgrazing, with particular reference to pastoral grazing in developing countries. The analysis also will be extended to other examples of externalities and to public or collective goods generally.

Overgrazing: Some Theoretical Approaches

In much of the developing world, common property provides a complex system of norms and conventions over individual grazing

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rights, closely resembling the traditional, common property institution of prefeudal Europe. Common property was an old Teutonic institution, which slowly gave way to the forced enclosure movements of the fifteenth and sixteenth centuries, notably in Great Britain. Its existence may be traced to Graeco-Roman times (Vassberg, Blum). Historically, and in its modern version, common property provides regulations of considerable complexity over individual grazing rights. Given its persistence, common property is argued by some scholars to be a relatively stable system (Dahlman).

As an institution, common property is distinguished from free and open access, where there are no rules regulating individual grazing rights (Ciriacy-Wantrup and Bishop). Often, what appears to the outside observer to be open access may really involve tacit cooperation by individual users according to a series of rules. This is common property. As in duopoly, a structure of use-rights to common range may be stable or unstable. It is this problem, not open access, which I will address. Empirically, it is important to distinguish between open access and common property if appropriate policy is to be formulated. The problems of open access arise from unrestricted entry. Problems of common property pertain to use-rights by a group of a given size.

Although common property may be a stable pattern of resource use in traditional societies, population growth, technological change, or rapid climate change can destabilize traditional institutions. Today, especially in areas of the Sahel and southern Africa, the breakdown of common property institutions has led to serious overgrazing (Hitchcock, Picardi and Seifert, Glantz).

Many economic consultants and planners have called for the imposition of private property rights to halt this "tragedy of the commons" (Johnson, Picardi). Following the tradition of enclosure of common grazing lands, efforts have been made to impose private property schemes to "internalize" a common property externality (Foss). Many have failed seriously. Not only have they failed to stop overgrazing, they also have contributed to further inequality in already unequal distributions of wealth. Lands formerly held in common are being transferred to individuals, such as high-ranking government bureaucrats, who can exercise influence in the allocation of use-rights. These individuals often fail to protect range quality (Hitchcock). An analysis of the economic paradigm leading to this failure sheds light on the problem.

The Property Rights Paradigm

Some economists argue that the proper solution for overgrazing a common range is to internalize its costs by making the public aspects of the range private. Instituting a scheme of such rights, if they are properly enforced, will create a market in the private rights to graze. This approach has led Demsetz, among others (Cheung, North and Thomas, Furubotn and Pejovich) to argue that the mere existence of common property rights over a scarce resource will lead to a tragedy of the commons because of the failure to internalize the social costs of grazing the last head of cattle. They argue that the enforcement of private use-rights to the resource will yield internalized costs to each user equal to benefits in total and at the margin.[1]

There are three things wrong with this analysis. First, it does not distinguish between situations of open access (in which the main difficulty is unrestricted entry) and those of common property.[2] This view implies the inevitable overexploitation of common property, an historically false position (Dahlman). Second, it treats the common property externality as if each individual's choices are independent of their expectation of others' choices. Thus, cost functions for each cattle owner are assumed separable in their arguments. Third, and most important, because individuals are assumed to act independently, the property rights paradigm abstracts from the crucial problem of each person's uncertainty about the actions of others.

The first of these problems is empirical. The next two are theoretical and require further elaboration. This may be provided with the

[1] The inherent inefficacy of common ("communal") property regimes in the property rights paradigm is expressed clearly by Demsetz. Demsetz asserts the "great disadvantage" of common property, since "the maximization of the value of communal property rights will take place without regard to many costs, because the owner of a communal right cannot exclude others from enjoying the fruits of his efforts and because negotiation costs are too high for all to agree jointly on optimal behavior" (p. 356).

[2] North and Thomas (p. 234), for example, describe the economic state of traditional pre-agricultural societies as one in which "[T]he natural resources, whether the animals to be hunted or vegetation to be gathered, were initially held as common property. This type of property right implies free access by all to the resource" (p. 234).

familiar prisoners' dilemma game. Its logical similarity to the common property approach in the property rights paradigm highlights the shortcomings of the latter in analyzing externality problems. The prisoners' dilemma, when generalized to more than two actors, is also known as the isolation paradox. The basic result is that collective decisions by independent actors produce inferior outcomes, unless an enforceable rule is imposed from outside the group. To the property rights school, this rule involves private, exclusive use-rights to the resource.

The Isolation Paradox: Independent Choice

The prisoners' dilemma is illustrated in the following gain-loss table.

First Prisoner	Second Prisoner	
	Not Confess	Confess
Not Confess	(1,1)	(10,0)
Confess	(0,10)	(5,5)

"Confess" or "not confess" represent the choices (or strategies) open to each of two prisoners. The ordered pairs indicate the number of years in prison which will result from a particular coincidence of choices. Imagine that the the prisoners are interrogated independently. Both know that if neither confesses, they will receive short sentences and spend a year in prison (1,1); if one confesses and turns state's evidence, he will be released, and the other will receive a heavy term of ten years (1,10), (10,0). If both confess, each gets five years (5,5). Assuming mutually distinterested motivation, the most reasonable course of action, represented by the pair (1,1), is unstable. To protect himself, if not to further his own interests, each has a sufficient reason to confess, whatever the other does. "Rational" decisions by each prisoner individually make both worse off. Even if communication between the individuals results in an agreement to observe choice (1,1), both have an incentive to break it (Sen). Even in repeated plays, the incentive always is to defect (Weintraub). Therefore, the noncooperative pair, (5,5), is a Pareto-inferior equilibrium.

Now imagine a community of N individuals who must graze cattle on a common range of fixed size. Each individual must choose to do one of two things. One is "stinting," or limited grazing on the commons. The second is grazing at a level which, while advantageous to the individual, ultimately results in exploitative overuse of the commons. If each individual formulates his grazing decision independently, the result is an N-person variation on the prisoners' dilemma. The cost of grazing to each individual is a function of the grazing decisions of all N individuals. If all cooperate and stint, then the common range is preserved and cattle remain healthy. Yet independently (even with communication), each individual has an incentive to defect and graze heavily in the near-term, overexploiting the range in the long run. Each individual believes that he will receive a higher profit if he grazes at an exploitative level rather than stints. The incentive structure is such that it does not matter which strategy the others choose. Therefore, grazing at an exploitative level strictly dominates stinting for each individual. Hardin, in his original article on the tragedy of the commons, wrote:

> The rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another . . . But this is the conclusion reached by each and every rational herdsman sharing the commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world which is limited. (Hardin and Garrett, p. 20; *Science*, p. 1244)

Curiously, it is individuals' independence that "locks them into" the tragedy. This is the same outcome Demsetz and the property rights school claim as the inevitable result of common property. The main features of this paradox are

(*a*) *Pareto-inferior outcome*. Each individual will choose independently to graze at an exploitative level, leading to a situation in which all are made worse off. All are led toward this noncooperative equilibrium.

(*b*) *Strict dominance of individual strategy*. The result of overgrazing arises independently of the expectations of each individual regarding the actions of others. Because the choices of each are logically independent, there is no problem of uncertainty about the actions of others.

(*c*) *Need for enforcement*. Even if an agreement is struck that specifies all will stint on the range, the strict dominance of individual strategy makes such an agreement unstable. Without compulsory enforcement imposed by an outside authority, any such agreement is unstable because each prefers

that the others stint while he defects and grazes exploitatively (Sen).

Even if individuals attempt to develop cooperative rules to enforce stinting they cannot resolve their problem because nobody has an incentive to keep such agreements. As a result, an enforceable rule must be imposed from outside. Institutional rules are viewed as exogenous to the problem at hand. Private property rights are consistent with this formulation because they can be imposed from outside, as with the parliamentary acts of enclosure. Because this approach starts from the (not always obvious) presupposition that individuals pursue strategies independent of the expected actions of others, the appropriate decision unit must be the private individual user. Also consistent with the strict dominance of individual strategy is the strong assumption that rational individuals will husband and conserve their own private range area at a rate consistent with the time preference of society as a whole.

If this formulation is correct, then only by imposing private property rules from outside can the group optimize its grazing. Any other alternatives are unstable because of the strict dominance of individual strategy.

This approach confounds situations of open access with those of common property, because its noncooperative assumptions leave no place for cooperative rules unless they are imposed and enforced from outside. The second objection is that this game structure treats externalities as if all cattle grazers behave like Robinson Crusoe. This implies "separability" of individual cost functions which, I will show below, is extremely implausible. The third, and crucial, objection is that by assuming the independent formulation of each individual's strategy, this approach does not deal with uncertainty regarding the actions of others. I argue that uncertainty is the major motivating force in overexploitation of common property resources.

External Costs: Separable and Nonseparable Cases

Imagine two representative cattle owners each of whom grazes cattle on a common range.[3] In a competitive situation, each individual cattle owner has a cost function for grazing on the common. They are

$$(1)\qquad \begin{aligned} C_1 &= C_1(q_1, q_2),\\ C_2 &= C_2(q_1, q_2),\end{aligned}$$

where C_1 and C_2 are costs to owners 1 and 2, respectively, q_1 is head of cattle grazed by 1, and q_2 is head of cattle grazed by 2. These owners are linked to each other through their individual cost functions which reflect external diseconomies of grazing. Increases in cattle grazed by 1 impose additional costs on 2, and vice versa. If each individual maximizes profits from cattle holding, they will equate price with marginal cost:

$$(2)\qquad p = \frac{\partial C_1}{\partial q_1} = \frac{\partial C_2}{\partial q_2}.$$

The welfare associated with cattle production on the common can be measured by the difference between social benefit and social cost. In a competitive situation, social benefit can be measured for the two owners by their total revenue,

$$\text{total revenue} = p(q_1 + q_2).$$

Social costs can be measured by total costs,

$$\text{total costs} = C_1(q_1, q_2) + C_2(q_1, q_2).$$

To maximize welfare, the joint profit function of the two individuals must be maximized, where π signifies joint profit, and π_1 and π_2 are the profit functions of the cattle owners:

$$(3)\qquad \begin{aligned}\pi &= \pi_1 + \pi_2,\\ &= p(q_1 + q_2) - C_1(q_1, q_2) - C_2(q_1, q_2).\end{aligned}$$

First-order conditions for a maximum are

$$(4)\qquad \begin{aligned}\frac{\partial \pi}{\partial q_1} &= p - \frac{\partial C_1}{\partial q_1} - \frac{\partial C_2}{\partial q_1} = 0,\\ \frac{\partial \pi}{\partial q_2} &= p - \frac{\partial C_1}{\partial q_2} - \frac{\partial C_2}{\partial q_2} = 0.\end{aligned}$$

Second-order conditions for a maximum are

$$(5)\qquad \frac{\partial^2 \pi}{\partial q_1^2} < 0, \frac{\partial^2 \pi}{\partial q_2^2} < 0, \text{ and}$$

$$\frac{\partial^2 \pi}{\partial q_1^2}\,\frac{\partial^2 \pi}{\partial q_2^2} > \left(\frac{\partial^2 \pi}{\partial q_1 \partial q_2}\right)^2.$$

An externality arises when either

$$(6)\qquad \frac{\partial C_2}{\partial q_1} \neq 0 \text{ or } \frac{\partial C_1}{\partial q_2} \neq 0,$$

[3] The exposition of separable and nonseparable externalities follows that of Davis and Whinston, although I have adapted their arguments to the case of profit-maximizing individual cattle grazers.

since (2) and (4) will not then coincide. Profit maximization by each individual will not give the greatest net social benefit possible because of the external effects of one's cattle on another's costs. For completeness, note that these external effects are diseconomies, so that

(7) $$\frac{\partial C_2}{\partial q_1} > 0 \text{ and } \frac{\partial C_1}{\partial q_2} > 0.$$

This much is standard.

A function is said to be separable if and only if

(8) $$f(x_1, x_2) = f_1(x_1) + f_2(x_2).$$

Consider the case in which the cost functions of the individuals are interrelated by external diseconomies but are separable in their arguments:

(9) $$C_1(q_1, q_2) = A_1q_1^n + B_1q_2^m,$$
$$C_2(q_1, q_2) = A_2q_2^r + B_2q_1^s.$$

Profit maximization is given by

(10) $$p = \frac{\partial C_1}{\partial q_1} = nA_1q_1^{n-1},$$
$$= \frac{\partial C_2}{\partial q_2} = rA_2q_2^{r-1}.$$

The key result is that each individual's marginal cost in the separable case is given entirely in terms of own cattle: q_1 for 1 and q_2 for 2. Davis and Whinston have shown that this result is formally equivalent to the strict dominance of individual strategy. Consistent with the noncooperative nature of the isolation paradox, if each individual formulates his decision independently, then his appropriate decision rule for profit maximization is "price equals marginal cost," as in (10).

A separable cost function leads to the same result as the prisoners' dilemma. Since marginal cost to each individual is defined entirely in terms of own cattle, then whatever the actions of the other individual(s), there is a unique number of own cattle that maximizes each individual's profit. This is no more than a restatement of the strict dominance of individual strategy. In sum, separability implies the dominance of individual strategy (Davis and Whinston).

The effect of separable externalities in grazing is simply to shift the total cost curve of any individual grazer by a constant equal to the magnitude of the external effect. Because marginal conditions are unaffected, the optimal number of cattle for each individual remains the same. A tax or subsidy scheme may then be used to correct the price system according to the classical prescription (Pigou, Meade). Davis and Whinston note that "the typical cases (of externality) with which the classical analysis has been concerned have, in fact, assumed the condition of separability" (p. 245). My purpose in treating separability in such detail is to show that approaches based on the strict dominance of individual strategy, such as the property rights paradigm, also assume separable individual cost functions.

When the assumption of separability is dropped, elements of interdependence and uncertainty are introduced which become difficult to handle with traditional tools and concepts. Because separability is formally equivalent to strict dominance of individual strategy, dropping separability implies interdependence of individual choice. Each individual bases grazing decisions on the expected actions of others.

Nonseparable Externalities

The joint use of a common grazing area is not a separable decision. Choices to graze cattle on a common range are not made by each owner in a vacuum. Rather, they are conditioned on expectations of the likely behavior of others. The common range has tied their welfare and decision making together (Netting, Rhodes and Thompson). In the nonseparable case, the externality enters the cost function of each individual in a multiplicative rather than an additive way, so that

(11) $$f(x_1, x_2) \neq f_1(x_1) + f_2(x_2).$$

For example, consider two cost functions for representative cattle owners of the following form:

(12) $$C_1(q_1, q_2) = A_1q_1^n + B_1q_1q_2^m,$$
$$C_2(q_1, q_2) = A_2q_2^r + B_2q_2^tq_1^s.$$

Profit maximization by each individual implies that

$$p = \frac{\partial C_1}{\partial q_1} = nA_1q_1^{n-1} + B_1q_2^m,$$

as well as that

(13) $$p = \frac{\partial C_2}{\partial q_2} = rA_2q_2^{r-1} + tB_2q_2^{t-1}q_1^s.$$

In contrast to the separable case, marginal cost is affected here not only by the variable under control of the individual, but also by the other's choice variable. Because each person's marginal conditions for profit maximization are affected by the grazing decisions of others, there is no well-defined decision rule for each individual. Externalities will not simply shift total cost by some constant, as in the classical, separable case. Instead, it is likely that the changed marginal cost to each individual caused by the actions of others will alter the slope of the total cost curve along its entire length. This is more plausible. We would not expect that grazing on a common range of fixed size would involve a constant externality independent of the number of cattle put on the range. One cattle owner's decision to graze cattle generally will depend on his expectation of the behavior of others.

In game-theoretic terms, this strategic interdependence implies that the strict dominance of individual strategy no longer holds. Each individual must take into account the actions of others in his decision to graze cattle on the commons. This defines the problem of the commons as decision making under uncertainty. This uncertainty, arising from the interdependence of choice, suggests a logical structure different from the separable case. Nonseparable externalities imply an alternative game structure.

In nonseparable choice problems, there is no unique solution for each individual. Because of the interdependence of choice and the resulting changes in the marginal conditions for profit maximization, the classical tax-subsidy solution breaks down because of the "twists" likely in the total cost curves. The presumed advantage of private property, which is rooted in the strict dominance of individual strategy, can no longer be justified on these grounds. Strict dominance no longer holds. In the nonseparable case, the imposition of private property is an attempt to impose separability on an inherently nonseparable externality. If it is to succeed, it involves creating a set of independent agents out of a community of individuals. While this may be one possible solution, the absence of strict individual dominance does not commend it as the only one. And the transactions costs likely to be incurred will not be trivial. Advocates of independent decision making may promote more costly responses to externalities than necessary by neglecting the interdependencies which exist.

Hence, nonseparabilities suggest that the main problem of common property externalities is uncertainty. This view is held by Dasgupta and Heal, who note that, "contrary to what is often claimed, the problem of 'the common' and the resulting suboptimality of the market equilibrium are *not* formally identical to an N-person version of the prisoners' dilemma game" (p. 59). They also argue that the N-person prisoners' dilemma is erroneous because it is characterized by dominant strategies by each agent. Properly formulated, the commons problem involves the interdependence of agents, such that it is in the interest of each to restrict output (to stint on the range) if that is the only way to get other agents to do likewise. Hence, "the guilty party is not the profit motive per se. Rather, it is the economic and legal environment in which the profit motive is allowed free play" (Dasgupta and Heal, p. 63)

This renewed emphasis on the economic and legal environment places the problem in an institutional context. It also permits reformulation of the problem of the commons. This problem of cooperation, in game-theoretic terms, is known as the "assurance problem."

The Assurance Problem: Interdependent Choice

The assurance problem (Sen) is an amended version of a game called "the Battle of the Sexes," discussed by Luce and Raiffa and Bacharach. This two-person cooperative game has the following payoff matrix, representing the gains and losses of two individuals. The man wishes that they go together to the dog races; the woman wishes that they go to the ballet. But each of them prefers to go together to either of these activities rather than to separate entertainments. This game of pure strategy pairs has two equilibrium points, both going to the ballet or both going to the dogs.

Man	Woman	
	Ballet	Dogs
Ballet	(1,2)	(−1,−1)
Dogs	(−1,−1)	(2,1)

The game is not one of conflict, like the prisoners' dilemma. It is a cooperative game

because there is no dominant strategy for either individual. Hence agreements, once made, contain no incentive to defect; both parties gain from adhering to the rules. The problem is assurance regarding the other person's intended action. The man and woman must correlate their expectations and cooperate through some rule which assures them that wherever they go, they will go together. The payoff matrix may be expressed graphically (fig. 1).

The shaded portion of the graph describes the outcomes which the individuals can achieve without cooperation by choosing their strategy independently, as in the prisoners' dilemma. This shaded portion may be derived more formally so as to illustrate the distinction between the prisoners' dilemma and the assurance problem. By formulating "mixed strategies" of the two and their associated payoffs, it is possible to trace out the "convex hull" shown in figure 1. This convex hull illustrates the gains possible from cooperative rules providing coordinated expectations, or "assurance."

For example, suppose that she goes to the dogs and he picks at random from his two choices, as shown in the payoff matrix above. Then his and her payoffs are given in the graph by the line LJ. Say that she goes to the dogs

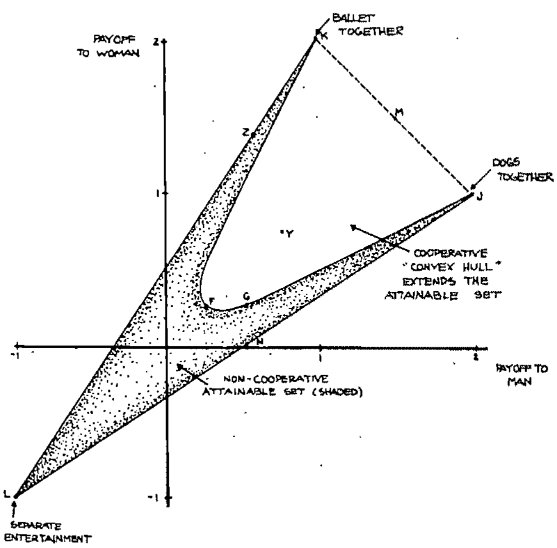

Figure 1. Payoff space: the battle of the sexes assurance problem

and he picks with probabilities half and half. His expected payoff is

$$1/2 \times 2 + 1/2 \times (-1) = 1/2.$$

Her payoff is

$$1/2 \times 1 + 1/2 \times (-1) = 0.$$

This gives the payoff pair of (1/2, 0), shown as the point N. Alternatively, suppose that each tosses an unbiased coin and goes to the dogs if it comes up heads. Then each of the four pure strategy pairs shown in the payoff matrix has a probability $(1/2)^2 = 1/4$. His expected utility and hers are the same:

$$1/4(2) + 1/4(-1) + 1/4(-1) + 1/4(1) = 1/4.$$

This gives the payoff pair (1/4, 1/4) at point F. The process can be continued with various probability combinations to trace out the convex hull. The important point is that when the choices of each are made independently, as in the prisoners' dilemma, it can be shown formally that the attainable set is only the shaded region of figure 1. This is the noncooperative attainable set.

However, cooperation enlarges the attainable set to include the entire area bounded by $LKJN$. In the assurance problem, the attainment of cooperative solutions such as point M requires coordinated strategies. These can arise only when the players' choices are interdependent and, recognizing it, the players devise a rule that provides assurance regarding the expected actions of others (Schelling, Bacharach).

The assurance problem provides a formal way of looking at interdependence and uncertainty associated with nonseparable externalities. Coordinated strategies evolve inside the structure of the game. In this sense, they mirror institutional rules which, by providing assurance, extend the set of possible solutions to allocation problems. By providing security of expectation, or assurance, reliable institutions are endogenous responses to the uncertainty of social and economic interaction (Taylor, Schotter, and Schelling).

Institutional Rules and Common Property Externalities in Grazing

The structure of the assurance game describes the problem of common property externalities in grazing. Its nonseparable character chal-

lenges the notion of strict individual dominance. It is more plausible to treat these externalities as problems of interdependence and uncertainty. Although Pareto-superior solutions may not be achieved, this structure—in contrast to the N-person prisoners' dilemma—does not make such solutions perpetually susceptible to defection and, therefore, inherently unstable.

The structure of the N-person prisoners' dilemma may be transformed into an assurance problem by dropping the assumption that individuals formulate their choices independent of the expected choices of others. When each individual expects everyone else to stint, that individual will stint, too. This has long been noted as an adaptive response in stable pastoral grazing economies (Brokensha, Horowitz, Scudder; Netting; Rhodes and Thompson). On the other hand, if each expects others to graze exploitatively, then each will also have reason to do so. In order to achieve the Pareto-superior outcome of range preservation through stinting, a coordinated strategy must be devised according to some set of rules or institutions.

Approaching overgrazing as an assurance problem provides striking perspectives in both analytical and policy terms. The strict dominance of individual strategy no longer holds. Consistent with the nonseparable common property externality, expectations of others' choices must be entered as a formal part of the determination of one's own choice. No individual can decide the preferred grazing strategy until it is known whether or not others will stint. A Pareto-inferior outcome no longer holds; if everyone is assured that the others will stint, then it is in their individual interest to do likewise. This outcome is not Pareto-inferior, since stinting is preferred by all in such a situation. If some assurance regarding the actions of others is provided, via an institutional rule, it is possible to achieve multiple equilibria in the extended "convex hull" of the attainable set. The lack of a dominant strategy for each individual cattle owner means that there are a variety of alternative solutions possible through cooperative action. Precisely which will be taken depends on individuals' bargaining power, their initial endowment of resources, their culture, climate, and so on. Analytically, the assurance problem's solution is an "equilibrium core" (Scarf, Shapley and Shubik). Unlike the prisoners' dilemma, cooperative solutions offer no incentive to defect. This suggests that institutional rules providing complete assurance are self-reinforcing; the incentive to keep them is that Pareto-superior solutions are attainable via cooperation which are unavailable otherwise. The key element determining the success or failure of institutions is therefore the extent to which they foster coordinated expectations (Ullman-Margalit).

It is hypothesized that the function of institutional rules is to parameterize expectations of the likely behavior of others. More precisely, "assurance" may be expressed in terms of the parameters describing—for each individual—the moments of a subjective probability density function over others' contribution to a public good. The moments of this function identify the expectation of stinting by others, the variance around this expectation, and the pessimism or optimism (skewedness) associated with it. Whether rational, self-interested individuals contribute to range quality by holding cattle off the range depends on the likelihood they attach to the level of voluntary contributions by others (Frohlich and Oppenheimer). The moments, notably the variance, of these density functions describe the level of assurance regarding these actions.

The virtue of institutional rules is that they are a relatively low-cost "shorthand" describing this expected behavior. Suppose that tribal tradition—the result of long-standing agreement—is such that each grazer is expected to stint at an arbitrary level (q^*). The result of this institutional rule is to formalize, for each grazer j, the expected actions of others at level q^*. Each expects the others to graze at level q^*, and, with this assurance, agrees to do the same (Brubaker). The rule extends the set of Pareto-superior allocations available to the tribe by preserving the range. Since communication and transactions needed to achieve cooperative institutional rules are not costless, agreement on the "shorthand" rule for grazing at q^* provides its own incentive to be retained as a tribal tradition.

A number of authors (Taylor; Frohlich and Oppenheimer; Frohlich et al.) have shown that an approach based on this interdependence of choice in the provision of public goods alters the conventional view of enforcement and the "size of the group." In particular, it challenges the well-known results of Olson, Buchanan (1968) and Russell Hardin, in which public goods, such as range quality, are seen as prisoners' dilemmas. These

conclusions, which depend on separability of individual cost functions, imply that expectations regarding the likely choices of others are not important, because for each, the strategy of not cooperating (i.e., exploitative overgrazing) is dominant. The only situation in which voluntary cooperation might be expected is when the group is small. Strictly speaking, even in small groups, the strategy of defection is still dominant without enforcement from outside.

If individuals' choices are interdependent, these results do not hold except under special assumptions about the shape of utility, cost, and production functions of the individuals (Taylor, Frohlich et al.). If expectations about the choices of others are relevant, then coordinated expectations are sufficient to generate voluntary contributions to a public good, independent of group size or outside enforcement (Frohlich and Oppenheimer, Marwell and Ames, Smith, and Bonacich et al.).

The relationship between the assurance problem and group size is that an individual's subjective estimation about the expected actions of others, notably its variance, generally would be expected to increase with the group size along with transactions and communications costs of finding an appropriate coordinating rule. But this is not true in every instance. The benefits derived from finding such a rule also might be expected to increase with the number of contributors, as would the opportunity cost of finding alternative rules.[4] The critical point is that institutions may succeed or fail whether the group is large or small (Taylor, p. 25).

A further point is the need for enforcement from outside the group. In principle, if institutions provide complete assurance, enforcement from outside the group is neither necessary nor sufficient for stable rules which insure nonexploitive grazing. A cooperative institutional rule providing complete assurance implies a total lack of uncertainty regarding the grazing behavior of others. Expectations are perfectly correlated, so that each individual's expectation of others' actions is concentrated around a particular level of grazing such as q^*. This is a limiting case, requiring perfect information and the absence of transactions and communications costs (Elster, pp. 20–23). These assumptions create a "perfect" solution to the assurance problem which is the institutional analogue to "perfect competition." In such situations, individuals have a sufficient incentive to contribute to range quality, without any need for outside enforcement (Frohlich et al., p. 328).

But what prevents someone from ignoring the rule at the expense of the others by "riding free"? The answer is that the benefits possible in the short term may be more than offset by costs arising within the group from breaking the institutional rule. In the absence of strictly dominant individual strategies, recognized interdependence makes the costs of reputation loss high. Pecuniary costs imposed by the group on its own noncooperative members also may occur (Akerlof). "Not to be trusted" in one circumstance may lead to a general loss of reputation, much like losing one's credit rating. These costs, plus reductions in the attainable set if such antisocial behavior "sets a trend" for others, plus the opportunity costs of innovating new rules, may well exceed the expense of stinting on the range. Because defecting or free-riding is not a strictly dominant strategy, enforcement is not a logical necessity.

This does not deny that in cases in which strategies are imperfectly coordinated (for whatever reason), enforcement from outside may help to achieve Pareto-improvements. For example, if cooperative agreements had led to a solution, such as point Y in figure 1, it might then be necessary for some enforcement from outside the group to move beyond point Y in the direction of line KMJ. This enforcement level would be significantly less than that required in a noncooperative environment. By allowing individuals full cooperative play, enforcement costs may be reduced. After exhausting cooperative rule-making potential, it may then be necessary to bind people by recourse to outside rules. But one should not jump, as in the prisoners' dilemma, to the conclusion that all such rules must be imposed and that people are not capable of binding themselves, like Ulysses, for their mutual benefit (Elster). The lesson of the assurance game is to let individuals have full freedom to innovate self-binding rules which best serve their needs before enforcing rules from out-

[4] Buchanan (1968, p. 91) was forced to conclude that "during period of extreme stress, such as was apparently evidenced by the British during World War II, behavior characteristic of small groups may have extended over almost the whole population." Smith concluded from an extensive series of recent experiments in public goods provision that "there appears to be no systematic effect of collective size or experience on the quantity of the public good provided" (p. 592). Similar results have been reported by Marwell and Ames, and Bonacich et al.

side. Rules will be better suited to the needs of the group (whatever its size) and more likely to succeed if based on this premise. These rules may come in many shapes and forms, not all of which are familiar. The institutional opportunity set of solutions to externalities is much wider than we think, and private property is only one.

Finally, enforcement from outside the group is not a sufficient condition for preservation of a public good such as range quality (Frohlich and Oppenheimer). The problem is that there is nothing to prevent the enforcing authority from abusing its position and putting control of land in the hands of a favored few with no interest in preservation or range quality. Any enforcement mechanism operating from outside designed to coerce provision of a public good must invoke a higher authority for its legitimacy. But this legitimacy is also a public good. Land grazing may be privately held and land titles enforced, but the "free-rider" problem will remain without cooperative institutional rules providing assurance within the group.

Conclusion

The assurance game suggests that cooperative institutional rules are endogenous adaptive responses to the problem of uncertainty about the expected actions of others, and that enforcement from outside is a second-order solution if these cooperative strategies are ineffective. The occurence of inferior outcomes, such as overgrazing, does not necessarily arise from the strict dominance of independent individual strategy. Rather, overgrazing results from the inability of interdependent individuals to coordinate their actions. In the pastoral grazing context, population growth, technological change, and climate changes make all such coordinated action more difficult than in more static settings.

Although I have focused on the role of institutional rules and assurance in problems of overgrazing, there are other common property externalities in which assurance problems may be even more important. With underground oil, coal, natural gas, or water, or with problems of air or above-ground water pollution, or with fisheries, it is simply infeasible to impose private property schemes since the common resource pool cannot be divided into discrete pieces. In these cases, the role of cooperative institutional mechanisms providing assurance takes on additional significance.

A key issue in this discussion is the way in which individual choice is modeled. Whether individuals are independent or interdependent is an empirical matter, but it is not without implications. Although everyday experience supports the interdependent view, the notion of "methodological individualism" has sometimes been used to support the argument that man is an independent actor, like Defoe's Robinson Crusoe. This view has deep intellectual roots, stretching back to Hobbes, and even earlier (Gonce). Yet Hayek noted that:

> Far from being opposed to voluntary association, the case of the individualists rests, on the contrary, on the contention that much of what in the opinion of many can be brought about only by conscious direction can be better achieved by the voluntary and spontaneous collaboration of individuals. The consistent individualist ought therefore to be an enthusiast for voluntary collaboration—wherever and whenever it does not degenerate into coercion of others or lead to the assumption of exclusive powers. (p. 16)

Traditional analysis, treating social choice as the product of aggregated independent individual choices, is given a much richer interpretation through the assurance game. Yet as Mishan noted in his survey of the externalities literature, "economists respond to the real world with a time lag, initially making use of more familiar, if less relevant, bits of apparatus" (p. 1). The familiar assertion of the strict dominance of individual strategy, reflected in the prisoners' dilemma, needs to be replaced with a richer framework.

This is not an argument against private property rights. Such rights may be an entirely appropriate institutional form, especially in societies based on the law of contract. But they are not the only institutional alternative nor the best in all circumstances.

The property rights paradigm, predicated in strictly individual strategies, misdiagnoses the grazing problem. By failing to recognize the endogenous character of property institutions caused by the interdependence of choice, it supports solutions which may be poorly suited to traditions of pastoral grazing societies. By seeking institutional rules imposed and enforced from the outside, it has promoted costly, top-heavy institutional regimes which restrict the potential for cooperative action. One example of such cooperative action is common property. The strict dominance of

individual strategy leaves no place for such solutions.

In the rapidly evolving economies of the developing world, a palpable uncertainty grips efforts to solve problems of growing populations and stagnant agricultural production. Traditional common property institutions may no longer suffice. However, efforts to impose institutions even more alien to the traditional, cooperative rules of a society may be profoundly destabilizing. If private property regimes fail as a solution in these societies, it is because they do not solve the problem of assurance.

Such assurance may require a decentralized approach to institution building based on the institutional norms and conventions of traditional cultures. Cooperative solutions are most likely to succeed where the locus of decision making is a relatively small, cohesive body. This is so, not because of the "size of the group" per se, but because assurance about the actions of others is largely a matter of information conveyed via transactions and communication. Information, organized as a set of rules, reduces uncertainty. In a larger sense it is information, rather than capital, that is the scarcest factor in rapidly changing agricultural societies. The free flow of information, and cooperative institutions which promote it, are most likely to occur at a relatively decentralized level.

Of course, enforced regulation from outside may still be needed. Since enforcement is expensive *vis-à-vis* voluntary cooperation, it should be a second-order solution.

It is ironic that the Hobbesian view of man's fate as a "war of all against all," so deeply imbedded in a strictly individualistic interpretation of economic choice, should lead property rights advocates to conclude that solutions to overgrazing must be imposed from the outside. The isolation paradox should be carefully analyzed by development planners and aid donors who are bent on exporting institutional forms which are a product of our own extraordinary history.

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Food Product Proliferation: A Market Structure Analysis

John M. Connor

The frequent introduction of avowedly novel products is a common marketing strategy of leading food manufacturers. Over half of all new packaged consumer goods are foods or beverages, yet little is known about the amounts, patterns, and causes of product proliferation. Alternative definitions and analytical models of product proliferation are reviewed, focusing on those derived from Hotelling spatial-equilibrium theory. A simple regression model is used to test the relationship of market structure to the number of new food products introduced. The results verify that food product proliferation is a mode of industry conduct arising from markets characterized by differentiated oligopoly.

Key words: food manufacturing, market structure, monopolistic competition, new product introductions, oligopoly, product differentiation, product proliferation.

In a recent *Journal* article, Padberg and Westgren chide agricultural economists for failing to analyze the important topic of new food product introductions. As they rightly argue, product proliferation is one of the major modes of competitive conduct by leading food manufacturers. Yet, little is known about the amount and patterns of new food product introductions. Even less is understood about how industry structure might affect product proliferation, but this is not surprising because structure-conduct links generally have received scant attention by economists (McKie). Not only may this dimension of conduct significantly affect economic performance, but also it may feed back on industry structure by increasing market shares of leading firms or by elevating barriers to entry.

Connor (1980b) has reviewed the reasons given by critics who regard product proliferation as one failing of the food system. First, they regard product proliferation as deceptive because most "new" products are mere imitations or minor variants on existing products and because they are marketed by the same few leading firms. Second, proliferation is said to exacerbate inflation because new products often have higher price/quality ratios than existing substitutes. Third, product proliferation entails waste in the forms of self-cancelling advertising, high failure rates, and suboptimal production levels. Fourth, the large number of new products introduced may undermine rational decisions by rendering trial purchase and evaluation difficult. Finally, product proliferation may be an anticompetitive strategy reinforcing product differentiation and raising barriers to entry.

While some food manufacturers might favor a nonproliferation treaty, they mainly regard new product introduction as an unequivocal benefit for their companies and consumers. Major firms think that new product programs are essential for firm growth, financially successful, and likely to become more important in the future (Hopkins). Manufacturers aver that product proliferation broadens consumer choice and, through market segmentation, satisfies consumer demand more precisely. Product introduction is equated with new entry; high failure rates are taken as evidence of strong competitive rivalry. (For a contrary view, see Abrams.)

Though few empirical studies exist, differing positions have been taken on performance implications of product proliferation. Abbott, for example, argues that product differentiation and product proliferation are superior

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substitutes for price competition with homogenous goods: "Non-price competition enhances the competitiveness of markets unless it is accompanied by barriers to imitation or by deceptive or diversionary advertising techniques" (p. 113). On the other hand, Scherer's (1980) summary judgment is that in markets where the proliferation of higher priced variants is the dominant mode of conduct, "more product variety is apt to materialize than the amount that maximizes social welfare" (p. 260).

This paper examines the extent of product proliferation among manufactured food products, its relationship to the market structure of the food-manufacturing sector, and some empirical determinants of new food product introductions. Economic theory suggests that product proliferation is an expected outcome in industries displaying a lack of "hard" or price competition. A model is tested to demonstrate that departure from competitive market structures are conducive to high levels of proliferation among processed food product classes. Finally, there is a brief discussion of the implications for consumer welfare.

The Concept of Product Proliferation

The term product proliferation is rather new and variable in usage. In this paper I use the terms "product proliferation," "new product introductions," "new product development," and "product-space packing" more or less interchangeably. (This usage is consistent with Scherer's 1980 revised textbook.) A common concept underlying most discussions of the subject involves a spatial analogy. That is, any given item can be categorized according to several attributes or dimensions; each dimension defines a product-attribute space that usually holds some empty or unfilled segments. Product proliferation consists of "filling" or making the space denser.

Product proliferation can be thought of as either a stock (state) or flow (rate). First, for a given well-defined market at a point in time, the level of product-space packing could be measured by a count of the number of variants in distribution or that number normalized to market sales. Second, product proliferation can be conceived as the gross or net flow of product variants into a market over a span of time. The number of new products introduced (possibly net of disappearances) could be expressed as a ratio by dividing by either the number of existing variants or total market sales. In this paper I generally use the gross rate concept of product proliferation.

This spatial concept can be used to distinguish "commodity-type" foods from physically "highly differentiated" foods. Products needing more dimensions to define them completely are more differentiated. For example: raw cow's milk reached the urban consumer of the early nineteenth century with only three or four dimensions (color, creaminess, freshness, and possibly water content). Milk was unpasteurized, unpackaged, unflavored, and unavailable in multiple butterfat levels. It had multiple end uses. Today, milk is more differentiated because, in addition to being branded, it is packaged in three or more sizes, three or more butterfat levels, and plain or chocolate flavored. As a result, most grocery stores carry at least a dozen fluid milk items. In addition, milk is now available in canned and dried forms that have more limited uses. Although fluid milk has been subject to modest product proliferation in the last one hundred years, it remains among the least differentiated of processed foods.

More differentiated products exhibit as many as ten dimensions. The attribute axes can be either continuous (e.g., sweetness) or discrete (e.g. type of packaging). For example, to adequately identify a particular ready-to-eat breakfast cereal the following information is needed: (*a*) basic ingredients, (*b*) preparation method, (*c*) shape and color, (*d*) organoleptic properties, (*e*) flavorings, (*f*) packaging, (*g*) time of manufacture, (*h*) intended occasion, (*i*) dietary characteristics, and (*j*) reference or target group. Though some of these dimensions may be irrelevant for a specific food, the ten characteristics should fully specify most contemporary food products. For each segment of the product-attribute space, there is a corresponding segment of potential demand. Changing any of these descriptors, especially the last three "psychic" attributes, implies a change in the demand segment to which the product corresponds. If a cereal is presweetened by frosting the flakes, then it could be re-aimed at another potential consumer group, young children perhaps. Reformulation implies a shift in the identity of close substitute cereals. The "repositioned" product would now compete in the "presweetened children's" segment rather than the "low-sugar adult" category.

Product proliferation is intimately related to the state of the arts. With a constant stock of technology and fixed demand, the introduction of physically differentiated products eventually would cease. In such a stationary world every available segment of the product space would become fully exploited and no additional products could be profitably introduced (Eaton and Lipsey 1975).[1] Technological change, however, can expand the product space by making additional dimensions possible, by adding more classifications on existing discrete axes, or by extending the range of continuous axes. Thus, technological change can be said to be a sufficient condition for product proliferation. It is not a necessary condition, however, because some physical differentiation (e.g., changes in package size) can occur with a static technology.

To illustrate, consider changes in kitchen appliance technology. The advent of the freezer led to the frozen replication of most canned goods. Microwave ovens imply the appearance of microwave-compatible foods and food packaging. Retortable pouches will permit another wave of proliferation. In these cases, technological innovation was a necessary condition for product proliferation, but consumer acceptance had to be won by convincing users of the inherent convenience, increased palatability, or compactness provided by further processing.

In addition to proliferation due to physical changes, persuasive advertising can create subjective perceptions or psychic differences among products (see Connor 1981). Advertising especially can alter the intended occasion, special identity, or target group of an existing product. The increasing importance of psychic satisfaction relative to physical needs appears to be related to affluence (Galbraith).

By dropping the fixed-demand assumption, product proliferation can occur even with a depleted technological reservoir. New demand for a particular segment of a product-attribute space can be generated by changes in income, demographics, or taste. Rising incomes may reduce consumer resistance to new products, most of which are higher priced than existing close substitutes. Smaller families, increased education, and more dual-career households probably have encouraged the introduction of smaller package sizes and convenience foods. Finally, many new food products have been marketed to satisfy consumer interests in low-calorie, "natural," ethnic, gourmet, and snack foods. Although the influence of demand on product proliferation is undeniable, it can be overrated easily. The mere availability of a new product creates some interest in it. Furthermore, new product promotion can shape household preferences. Thus, satisfactory analysis of product proliferation may require models that allow for simultaneity among supply and demand factors.

Packaging changes may be the most prominent form of food product proliferation (Arthur D. Little). It is certainly one of the most obvious. Packaging permits food manufacturers to offer multiple units and a nearly infinite gradation of sizes. More important, packages can deliver messages indicating possible use, occasions for use, and the appropriate reference group. Thus, purchasers can be told that a breakfast cereal also can be used as a snack or baking ingredient. Packaging changes can induce product proliferation by expanding the supply space, altering corresponding demand segments, or changing the mappings between the two sides of the market.

Two other dimensions of product proliferation are brand and price. Neither necessarily implies physical differences in products, but either can create differences in the minds of consumers. Trademarks can serve to collapse several product dimensions for consumers. Thus, some trademarks like "Shredded Wheat" carry a nearly generic connotation for several physical characteristics. If alternative descriptions like "Woven Wheat Pillows" are unattractive, product proliferation in the ready-to-eat breakfast cereal market may be reduced. On the other hand, branding can facilitate product proliferation. An example of brand-driven proliferation is where manufacturers make multiple brands of the same products. This may occur when two regional manufacturers in the same industry merge. More commonly, private label products are manufactured according to precise retailer specifications, but when two or more retailers use

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[1] Eaton and Lipsey extended the Löschian location model under the assumption that demand was evenly spread over the space. They demonstrated that entry (new product introductions) can always be forestalled if the space is packed densely enough; conversely, entry will always occur if the space is packed loosely enough. By relaxing the usual Löschian assumption of zero conjectural variation (i.e., they permit existing firms to have pricing reactions caused by entry), they derive equilibria that generate positive profits and barricaded entry that depend only on the density level.

the same specifications, then only the labels are different.

Within a well-defined category of products, there are likely to be fairly wide and sustained retail price differences, especially between national brands and first-line private label products. While many consumers use price as a guide to quality, a reasonably thorough review of evidence from laboratory tests and consumer taste panels found no such relationship (Parker and Connor). This is also confirmed by two formal analyses of correlations between price and quality ratings by *Consumer Reports* magazine for a wide array of manufactured products (Morris and Bronson; Swan).[2] Usually, wholesale price differences among the leading national brands of a given product are so slight that resulting retail-unit-price differences are nearly imperceptible to consumers. Some food manufacturers do use large price differences to create either a luxury or austere image for similar products. If they are extreme enough (e.g., "premium" and "superpremium" beers), two or more distinct product categories may be created. Mass-media advertising by food manufacturers is rarely used to inform consumers of suggested or actual price differences (Resnik and Stern; Stern, Krugman, Resnik). Of course, temporary discounts, specials, and other deals do create noticeable, if brief, price differences which may be highlighted in local retailer advertising.

Theories of Product Proliferation

Interest by economists in the phenomenon of multiple products dates back at least to Hotelling's classic paper on the competitive distribution of sellers. His model postulated consumers equally distributed along an axis representing distance between sellers or some qualitative aspect of a product, such as the sweetness of cider. With free entry and price competition, established sellers will produce cider of average sweetness in order to attract as many consumers as possible. If, on the other hand, entry is restricted or if the sellers agree to avoid price competition, then makers will produce ciders differentiated from each other by sweetness. Competition becomes localized in the sense that changes in quality (or price) only affect the demand for adjacent brands. Each producer is, in effect, an oligopolist, with groups of adjacent producers serving segments of the cider market based on differing sweetness preferences of consumers.

Hotelling's spatial-equilibrium model and Lösch's location model have been extended by analogy to incorporate product (nonspatial) differentiation.[3] Like sellers or plants separated in space by physical distance, the proximity or distance of products in product-attribute space is a measure of qualitative differences. Price differences are analogous to transportation costs. Numerous analyses consider various assumptions about potential entrants' expectations. These analyses have shown that when products are differentiated, even the existence of free entry may not suffice to eliminate excess profits (Lovell; Peles; Hay; Stern; Eaton and Lipsey 1975, 1976; Prescott and Visscher).

Scherer (1979) has developed a simple model to explain the criterion used for launching a new consumer product. Whether or not a new product will be marketed depends on the gain in the discounted present value of producers' surplus relative to the fixed costs of introduction (research and development, market research, test marketing, introductory advertising, and additional plant capacity). The size of the potential producers' surplus is in turn affected by the market structure. Under Cournot-like reaction assumptions and free entry, monopolistic competition yields higher surpluses than pure monopoly. Alternative assumptions about entry conditions and oligopolistic reactions yield different potential gains in producers' surplus. The entrant's surplus (transfers from consumers, pure

[2] All the tests of quality differences cited predate the appearance of so-called generic grocery products. Like the second-line, private-label items previously offered by some retailers, generics typically utilize less costly ingredients and packaging. On the other hand, at least one major grocery chain sold their regular first-line private label products with generic labels affixed. Generics are usually priced 25% to 35% less than the leading national brand equivalents.

[3] Two other theoretical approaches also have been used to examine product diversity. Dixit and Stiglitz adopted an orthodox consumer-utility framework to analyze optimal product diversity. Lancaster has studied the same problem using his characteristics-preference model. Ironmonger also used a consumer demand approach to analyze the impact of new commodities on demand elasticities and their life cycles. Though formally similar to spatial equilibrium models, theories of consumer demand have not been useful for introducing market-structure characteristics on the sellers' side.

Chamberlin, Spence, and Scherer (1979) also may be considered a distinct tradition interested in the phenomenon of product diversity. Utilizing the concepts of monopolistic competition and Marshallian consumers' surplus, they have attempted to measure or predict the social welfare impacts of product proliferation. See the final section of this paper.

surplus, and transfers from other producers) varies considerably depending on the substitutability between new and adjacent products.

Schmalensee has constructed a more formal, spatial-equilibrium model to analyze product proliferation in a differentiated food-manufacturing industry. He demonstrated that, if established firms collude to deter entry, then increasing the number of brands of a given product is more (jointly) profitable than "limit pricing," the strategy of limiting entry by lowering prices, thus sacrificing short-run for long-run profits. In an industry characterized by brand proliferation, an equilibrium is possible in which established brands earn excess profits but no potential entrant can profitably enter. He also deduced that brand proliferation deters entry by unbranded (private label) imitators more effectively than does limit pricing.[4] Finally, Schmalensee demonstrated that excess advertising is an effective alternative to brand proliferation for deterring entry. While Schmalensee's results depend on the existence of localized rivalry (brands are immobile in the sense that a repositioning in quality space is too costly for a seller to consider), relaxation of this assumption to finite repositioning costs does not appear to alter his conclusions (Eaton and Lipsey 1975).

Another theoretical approach to product proliferation is "commodity bundling." In a formal model developed by Adams and Yellen, bundling includes products available in different containers, multiple unit packages, and "incarnations of the same product, differing in either real or perceived quality" (p. 475). Their model assumes a monopolist selling either two noncomplementary products with equal unit cost curves or a single product with two separable characteristics. They demonstrate that pricing strategies can be followed to extract consumer surplus by sorting buyers into groups with different reservation prices. Bundling is similar to price discrimination and under some conditions a more profitable strategy. Finally, their normative analysis of commodity bundling concludes that it generally produces nonoptimal product quantities and causes a significant redistribution of income from buyers to sellers.

A less formal analysis of product proliferation is in a recent paper by Koller. He considers product proliferation as one of the three most common forms of predatory conduct, far more prevalent today than classical predatory pricing. Proliferation conforms to the three criteria of successful predation: (*a*) the predator earns quasi-rents, (*b*) the market is restructured, and (*c*) rivals or buyers are made worse off. Consumers may be better off initially because of the availability of new products, but eventually they are worse off because proliferation preempts entry by actual or potential competitors. Koller argues that, because the investment is covert and because the barrier is erected as soon as the product is marketed, proliferation takes rivals by surprise, thereby making it generally more effective than predatory pricing wars. Because of employee turnover, test marketing, and industrial spying, in actual practice secrecy is difficult to maintain, thus blunting the element of surprise.

In sum, economic theory suggests that new grocery product development is primarily a form of nonprice business conduct whose roots lie in market structure. A firm that already holds a leading position in a given market will find it advantageous to develop products in adjacent product-space niches for several reasons. First, adjacent products may appeal to a new set of consumers and offer present consumers additional variety. Developing products in adjacent positions may also be an effective defensive strategy to maintain market share for a firm's leading items (Friedman). Second, the firm eventually may be able to offer a full line of products. A full line allows a brand name to be more fully exploited, may justify employing a field sales force, or may confer some pecuniary economies of scale in advertising and promotion. Third, product proliferation of this kind generally will require the allocation of substantial retail store shelf space. In order to duplicate or imitate the line, a new entrant would require a similarly large allocation of shelf space by retailers. Because this is unlikely for all but the most powerful of manufacturers, product proliferation is a barrier forestalling entry at the retail level. Fourth, being the first or second in

[4] In a personal communication Schmalensee notes that in the breakfast cereal industry, some private-label manufacturers find entry foreclosed because the brand has achieved a nearly generic identification; in these cases, attempting to identify the contents of a box of an imitative breakfast cereal might constitute trademark infringement. A related device is "trademark banking." This practice consists of registering numerous variants of successful or potentially useful brand names far in advance of actual introduction; most are never used. One major food manufacturer has over 1,300 trademarks registered in the United States.

a market has been shown to confer future high market shares (see, for example, Whitten).

Measuring Product Proliferation

The concept of a "new" food product varies widely from writer to writer. Some claim that there are no truly new foods, while others estimate that several thousand new foods appear each year The problem of definition depends partly on the point of view of the agent in the food system; as Buzzell and Nourse have argued, manufacturers, retailers, and consumers each have differing perceptions of newness.

Buzzell and Nourse proposed that new products can be classified according to their degree of novelty. This paper will follow their lead. First, the rarest and most innovative product introductions will be termed distinctly new products, types, or categories. Second, a more common kind of product proliferation is brand proliferation (imitations of successful new types by other producers) or line extensions (by the introducing firms). Finally, the most frequent type of proliferation will be called item proliferation, repositioning, or reformulation. These distinctions also fit within a time framework. That is, first, a new category is created; second, brand proliferation or line extensions occur; third, item proliferation and repositioning are observed.

Connor (1980a) reviewed four secondary data sources on new grocery product introductions. Two sources detailed their selection of distinctly new food products. Buzzell and Nourse identified only 22 such products in the 1945–65 period. The editors of *Progressive Grocer,* on the other hand, selected about 25 food products introduced in the late 1970s as especially innovative. *New Product News,* a trade magazine, found that on average nearly 900 new brands of packaged consumer goods were being introduced yearly during 1964–70; item proliferation (excluding package sizes), however, was considerably greater, averaging over 1,950 per year. In both cases, product proliferation showed a steady upward trend after 1973. More than half of all food and beverage proliferation in 1977 was accounted for by frozen foods, candy, beverages, and snack items.

Grocery warehouse withdrawal records are a fourth source of new product introductions. Though these records do not count nonwarehoused or direct-store-delivery items (e.g , produce, perishable dairy items, and fresh bakery products), they provide a very complete and most cited accounting of new branded grocery products. For example, the Nielsen Early Intelligence System (NEIS) found that an average of more than 6,000 items entered national distribution per year during 1973–78. More than 5,000 per year were edible products. The NEIS data indicate a much larger number of new item introductions than *New Product News* because the former includes even trivial package size changes or additions. Because some existing items must be dropped to make room for the new, the average net increase of grocery items in U.S. wholesale distribution was about 4.7% per year in the 1973–78 period.

A final data source on product proliferation is a report of "significant" new consumer packaged products compiled monthly for many years by the staff of *Advertising Age* magazine. Because these data provide information on individually identified new products, they form the basis for the statistical analysis in the next section. In particular, it was possible to classify each product by its five-digit SIC number (the Standard Industrial Classification system divides manufactured foods into 130 five-digit product classes), determine the parent company for each brand, and eliminate the mere "repositioning" (change in advertising appeal or theme) or "reformulation" of products. New flavor varieties were counted, but new sizes and redesigned packaging were ignored. Regional and national offerings of new products were counted, as were full test-marketings. Thus, these *Advertising Age* data include brand proliferations or line extensions but not mere item proliferations.

Five categories account for over 50% of the introductions (table 1); about 53% of 732 new products recorded were processed food or beverage products. The high proliferation categories are generally characterized by high concentration, high advertising intensities, and other oligopolistic market features (Connor 1980c; canned items were predominantly canned ethnic specialties; the frozen foods, mainly frozen pizza and entrees). There was a relatively low rate of brand proliferation in two nearly monopolized industries, baby foods and canned soups.

Most product proliferation can be attributed to firms already established in food process-

Table 1. New Packaged Consumer Food and Tobacco Products Introduced by Product Category, 1977–78

Product Categories	New Products Introduced[a] 1977	1978
Nonalcoholic beverages and mixes	32	38
Alcoholic beverages	21	28
Pet foods	20	19
Flour mixes and baking ingredients	18	10
Frozen foods	18	12
Tobacco products	16	7
Canned fruits, vegetables, and specials	14	12
Candy and chewing gum	11	16
Breakfast cereals	10	14
Meat and fish	10	1
Bread, cakes, crackers, and cookies	9	11
Dehydrated vegetables and soup mixes	9	6
Dairy products	7	4
Chips	5	11
Margarine and oils	3	4
Prepared desserts	3	0
Baby foods	2	0
Canned soups	1	0
Sauces and dressings	1	0
Total	210	209

Source: Compiled by the author from *Advertising Age*, Feb. 1977 to Jan. 1979.
[a] A simple count of all new brands, flavors, and line extensions. Minor changes in packaging, different package sizes, reformulations, and repositionings were not counted.

ing. Of the 419 new food and beverage products introduced during 1977–78, 59% were introduced by the 50 largest food or tobacco processing firms, and 70% originated from among the 200 largest. Only 11% of the products were marketed by firms with no recent products in the category. Because *Advertising Age* depends to some extent on announcements distributed by the firms themselves, these data may be biased toward larger firms. However, they are consistent with the *New Product News* data for 1977, which shows that only 15 large firms account for nearly 20% of all products.

The Model

The model tested here is a simple, linear equation which assumes that market structure elements (and control variables) impact additively on brand proliferation. The dependent variable is a simple count of the total 419 new branded food manufactures introduced into each of 102 product classes during 1977–78 (see appendix table 1 of Connor 1980a). Because the dependent variable takes on only a limited number of integral values, it has a multinomial distribution and the estimated coefficients and t-tests only approximate the true values (Kmenta, pp. 425–27).

The independent market-structure variables refer to 1972–75 data.[5] To model the potential for cooperation among established sellers, the four-firm sales percentage concentration ratio (*CR*4) is utilized. The square of four-firm concentration (*CR*4*SQ*) was added on the expectation that tight oligopolies (canned soup, infant foods, etc.) may have densely packaged product-attribute spaces. This discourages a high rate of product proliferation because existing, adjacent variants are close substitutes for contemplated new variants. The extent of product differentiation is captured by the percentage eight-media advertising-to-sales ratio of the top four firms in each product class (*ADS*). The estimated coefficient of *ADS* may be biased upward because of the heavy introductory media advertising associated with many new products. The final structural variable is the percentage of direct production costs incurred by the census industry for packaging materials (*PACKCOST*). Just as media advertising intensity is expected to capture the extent of differentiation in the psychic attributes of food products, heavy packaging costs may be a proxy for the ease with which food products can be physically differentiated from one another. Also, packaging may serve to reinforce media advertising messages.

Control variables also are introduced into the model. The natural logarithm of the 1975 wholesale shipments value of each product class (*SIZE*) is a proxy for the density of potential demand for new products. All else held constant, a large product class is likely to have a larger number of exploitable demand segments than a small product class. The percentage change in product class shipments value during 1967–72 (*GROW*) is designed to reflect shifts in demand and tastes which likely encourage product proliferation. On the other

[5] These data were originally developed for Parker and Connor. Appendix D of their working paper contains definitions, sources, and a complete listing of the values of the independent variables for all 102 consumer product classes in the food-manufacturing industry. Following census practice, ten product classes (e.g., 20116 and 20136) were combined into five observations.

hand, past high growth rates may identify product classes with high proliferation in the past and densely packed classes in the present. Thus, *GROW* could be negatively related to the short-run rates of proliferation being explained in the present model. The final control variable is *PLSHR*, the percentage of the product class' sales in private-label products in 1976 (if unreported, it was assumed to be zero). Because *Advertising Age* compiled data on new branded products only, the larger the private-label segment of the market, the less likely are new products to be introduced into the branded segment. In a sense, *PLSHR* is a correction for *SIZE*.

The independent variables *CR4*, *ADS*, *PACKCOST*, and *SIZE* are expected to exhibit positive regression coefficients; *PLSHR* and *CR4SQ* should be negative; and *GROW*'s effect is ambiguous. The units of observation are the 102 consumer products classes in food manufacturing (*SIC* 20).

The Results

The OLS regressions are displayed in table 2. The simplest equation (2.1), explains only 23% of the variance in levels of product proliferation. Both structural variables have the correct signs; advertising intensity is significant at the 1% level; and *CR4* is significant at the 5% level. The inclusion of *SIZE* in equation (2.2) and all succeeding equations markedly improves the goodness of fit; it is highly significant and positive as expected. A parabolic specification is used for seller concentration in equations (2.3) through (2.7). The second-degree term *CR4SQ* is significant, the critical point being reached between the 60% and 70% concentration levels. In equation (2.4) *PACKCOST* is significant and displays the expected positive relationship with product proliferation. The reduction in the size of the coefficient on *ADS* indicates that media-generated and physical differentiation are to some extent substitutes in food industries. Long-run past growth has no significant influence on new product introductions, equation (2.5), but the share of the market going to private-label sales has a weak negative impact as expected, equation (2.6). The final equation combines all six factors. Overall, equation (2.4) appears to be the best-fitting model, with four factors explaining nearly half of the variance in brand proliferation among processed foods. An examination of the residuals found no evidence of heteroskedasticity, nor did multicollinearity appear to be a problem.

The regression analysis indicated that prod-

Table 2. Market Structure Determinants of the Number of New Packaged Foods Introduced, 1977–78

		Independent Variables[a]							General Statistics[b]	
Equation Number	Constant Term	*CR4*	*CR4SQ*	*ADS*	*SIZE* natural log	*PACKCOST*	*GROW*	*PLSHR*	R^2	*F*
2.1	−2.72	0.07[b]		1.40[a]					0.23	14.4[a]
		(1.68)		(4.49)						
2.2	−15.71	0.07[b]		1.40[a]	2.02[a]				0.33	15.9[a]
		(1.81)		(4.82)	(3.85)					
2.3	−22.79	0.35[b]	−0.003[c]	1.40[a]	2.06[a]				0.34	12.6[a]
		(1.87)	(1.53)	(4.85)	(3.95)					
2.4	−26.60	0.37[b]	−0.003[b]	0.96[a]	2.16[a]	0.13[a]			0.45	15.9[a]
		(2.17)	(2.01)	(3.36)	(4.50)	(4.38)				
2.5	−23.32	0.34[b]	−0.003[c]	1.45[a]	2.15[a]		−0.013		0.35	10.2[a]
		(1.84)	(1.51)	(4.87)	(4.00)		(0.71)			
2.6	−22.43	0.34[b]	−0.003[c]	1.34[a]	2.22[a]			−0.05[b]	0.36	10.9[a]
		(1.84)	(1.58)	(4.65)	(4.23)			(1.70)		
2.7	−26.62	0.36[b]	−0.003[b]	0.98[a]	2.35[a]	0.13[a]	−0.13	−0.04	0.46	11.6[a]
		(2.11)	(2.01)	(3.38)	(4.70)	(4.12)	(1.25)	(0.80)		

Source: Data compiled by the author from *Advertising Age* and Parker and Connor.

[a] *t*-statistics in parentheses; [a], [b], and [c] superscripts indicate statistical significance at the 1%, 5%, and 10% levels, respectively, using one-tailed tests.

[b] R^2 is the coefficient of multiple determination; *F* is the *F*-statistic.

uct proliferation was unrelated to industry growth. Several other factors were tested and found to be insignificant. Three variables representing barriers to entry were developed: the ease of foreign entry as represented by high U.S. imports and two economies-of-scale barriers to entry. Three variables representing industry progressiveness also were tested. One, the ratio of research and development expenditures to sales, is a measure of innovative effort. Two others attempted to capture technological progressiveness on the output side: the number of U.S. patents assigned to food companies (principally classified in the industry) during 1961–75 and the number of scientific and technical publications by food company employees during 1965–75. However, neither economies of scale nor technological progressiveness were significantly related to food product proliferation. The latter finding is rather surprising, because many writers have inferred that inventiveness would lead to innovativeness as revealed by new product marketings. However, it is possible that food-manufacturing inventiveness effects improvements our data do not measure. Alternatively, progressiveness in other industries, for example the packaging industry, may improve the quality or increase the quantity of food products.

The empirical results confirm that imperfect market structures do indeed generate high levels of food product proliferation. There is a significant relationship between brand proliferation and the concentration of sales and advertising intensity. With an industry structure regarded as workably competitive ($CR4 = 40$, $ADS = 1$), equation (2.4), holding *SIZE* and *PACKCOST* at their means, predicts about 1.5 new products per year per product class. Higher levels of concentration and advertising, say $CR4 = 60$ and $ADS = 10$, imply the introduction of 11.5 new food brands per year per product class.

The results reported here for the food-manufacturing industries provide empirical support for the market structure-conduct linkage suggested by Schmalensee's model. Product proliferation is one of several forms of business conduct open to firms in oligopolistic industries with differentiated products, but it appears to be a widespread strategy in the food industries. This paper has not dealt directly with the normative or performance impacts of food product proliferation, but they are likely to be profound.

Normative Implications

Theoretical treatments of the welfare effects of product variety are inconclusive. The existence of a trade-off between the increased satisfaction that consumers derive from being able to match their tastes more precisely to market offerings and the decreased welfare effects of higher product prices has long been recognized (Chamberlin 1933). More recent formal welfare analyses of optimal product diversity have arrived at no clear judgment on the net effects (Lancaster; Dixit and Stiglitz; Stern; Spence). Schmalensee likewise argues that there are not necessarily too many products for a given market even though product proliferation deters entry. However, his analysis suggests that in such markets some reduction in prices, holding the product mix constant, would trivially increase net welfare.

There are two studies that have attempted to assess the social value of food product proliferation. Nyström and Edvardsson attempted to measure the producer and consumer benefits of all 121 new food products introduced during 1969–78 by the twenty Swedish food-processing companies most active in research and development. Their performance standards (technological novelty, taste quality, convenience, nutritional value, price relative to closest existing substitute, and profitability) were largely judgmental. From the point of view of consumers, about one-third of the new products were ranked superior and one-half the same as existing close substitutes.

More formal estimates of the welfare benefits of product proliferation are given in a recent paper by Scherer (1979) on the ready-to-eat cereal industry. He estimated the fixed costs of introduction, producers' surplus gains, and consumers' surplus gains for seventy-six ready-to-eat cereal brands introduced during 1958–70. The average minimum fixed costs were $4.4 million per brand (1962 dollars). By the mid-1960s industry growth had become flat; as a result consumers' surplus declined and new product introductions increasingly involved only interproducer transfers ("cannibalization"). Both the prices and profit margins for new ready-to-eat cereals averaged about 30% higher than existing brands, which led to substantial transfers from consumers' to producers' surplus. Nevertheless, consumers' surplus averaged about 20% of wholesale prices. By his calculations, about

22% to 30% of the brands introduced (33% to 43% of those introduced beyond the regional-test stage) generated positive net social benefits. In sum, "it appears probable that product proliferation has, at least at the margin, cost more than it was worth" (Scherer 1979, p. 133).

Taken together, these studies suggest that product variety in mature, highly oligopolistic food industries may be excessive. Henning and Mann (p. 262) strongly advocate public policies limiting product proliferation, primarily because they consider it a major cause of excess advertising. Padberg and Westgren opined that traditional antitrust remedies are unable to deal with the performance impacts of product proliferation. I am aware of only one piece of U.S. legislation that was prompted by a concern about proliferation; the Fair Packaging and Labelling Act of 1966 directed the Department of Commerce to reduce the proliferation of packaging sizes via voluntary industry agreements.

The belief that product proliferation is an anticompetitive practice was an important element in the decision of the Federal Trade Commission to bring its eight-year-old antitrust case against the major ready-to-eat cereal companies. Because no economic norm of optimal product diversity has yet been developed, and because measurements of product proliferation are subjective or arbitrary, the direct regulation of industry performance or structural improvements may be public policy approaches superior to policies tailored specifically to optimize rates of product proliferation.

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A Sector Analysis of Alternative Income Support and Soil Conservation Policies

W. G. Boggess and E. O. Heady

For nearly five decades Congress has attempted to legislate both higher farm incomes and soil conservation. A national, interregional, demand-endogenous, separable programming model is used to analyze the potential of alternative policies to achieve simultaneously the dual goals of increased farm income and reduced soil erosion. The analysis indicates that a conservation-oriented land retirement policy can be designed to achieve an increase in net farm income equivalent to a traditional general land retirement policy, while simultaneously achieving significant reductions in gross soil erosion, chemical input use, and direct government program costs.

Key words: endogenous demands, income support, interregional analysis, separable programming, soil conservation.

The United States has a long history of government intervention in agriculture. Efforts to legislate soil conservation began with the Soil Conservation and Domestic Allotment Act of 1936 and continue today. This study assesses the potential of alternative policies to achieve simultaneously the dual goals of increased farm income and reduced soil erosion.

Following the method outlined by Duloy and Norton, a national interregional separable programming model of the U.S. agricultural sector is formulated. Four alternative combinations of supply control and soil conservation policies are analyzed to ascertain their impact on regional farm prices and incomes, farm output, farm input use, and gross soil erosion.

Model Specification

Previous agricultural policy models have included both mathematical programming models (Taylor and Frohberg, Stoecker, and Meister et al.) and simulation models (Tyner and Tweeten, Ray and Heady, and Ray and Richardson). Mathematical programming models provide normative answers to problems. Normative courses of action are those which ought to be taken by the agricultural sector, given (*a*) the particular objective function specified and (*b*) the conditions and restraints surrounding the alternatives available (Heady and Candler). In contrast, a positive analysis predicts how farmers would actually respond to a particular policy. Both types are needed.

A mathematical programming model is used here because it can help analyze policies in which the underlying structural framework changes. Furthermore, it provides the regional detail necessary for analyzing the interregional impacts of the alternative policies. (McCarl and Spreen present an excellent discussion of the usefulness and limitations of mathematical programming for policy analysis at the sector level.)

The model provides comparative static rather than dynamic analysis. The optimum plan, after implementation of a policy or structural change, is compared to the optimum plan before implementation of the policy or structural change. This comparison shows the impact of the change on the response variables. It does not, however, provide information on the dynamics of moving from the old to the new optimum plan.

A mathematical programming problem consists of a simultaneous equation network rep-

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resenting the constraints on the system plus an additional equation to represent an optimized functional relationship. A mathematical description of the model follows.

Objective Function

The objective function maximizes the area between the demand and supply curves. Linear demand functions for beef, pork, milk, wheat, oils, and feed grains are of the form,

$$\mathbf{P} = \mathbf{A} + \mathbf{BQ}, \tag{1}$$

where **P** is the price vector, **A** is the intercept vector, **B** is the matrix of slope coefficients, and **Q** is the vector of quantities. They are estimated and incorporated into the model structure. The intercept and slope coefficients were obtained from an updated version of Stoecker's quadratic programming model using 1985 projected populations and incomes.

Following Duloy and Norton, grid linearization (separable programming) techniques are used to incorporate the interdependent demand functions endogenously in a linear programming context. Given the demand relationships in equation (1), Duloy and Norton formulated an objective function which maximizes the area between the demand and supply curves represented mathematically[1] as

$$\text{(2)}\quad \text{maximize } Z = \int_0^{q_n} \cdots \int_0^{q_1} (A + BQ)\, dQ - C(Q) = Q'A + .5\, Q'BQ - C(Q),$$

where $C(Q)$ represents the supply side of the market. The model treats input prices as fixed. Implicitly, this is equivalent to assuming that the supply functions for inputs are perfectly elastic. In reality, changes in sector-wide demands for inputs could have significant impacts on input prices and thus production costs and farm income. As output expands, the demand for, and thus the price of, inputs normally will rise unless the input supply functions are perfectly elastic. Allowing input prices to rise in response to an increase in demand will result in proportionately greater increases in production costs and a proportionately smaller increase in net returns than are suggested by this model. The rising input prices also would tend to dampen the output response relative to that exhibited by this model. If input supply elasticities are available, the separable programming framework can be modified to incorporate endogenously the price effects of changing demands for inputs following the approach outlined by Hazell.[2]

Equation (2) is quadratic in Q. Expansion of the term $.5Q'\ BQ$ results in squared and cross-product terms. The cross-product terms are not separable, and a transformation is required to obtain separable functions. The separable variables in equation (2) were modelled using the IBM MPSX separable programming routine.

The overall objective function incorporating both the separable demand and the supply sides of the markets may be expressed mathematically as

$$\text{(3)}\quad \max.\ Z = \sum_n \sum_s A_{ns}Q_{ns} + \sum_n \sum_s \sum_r \sum_v B_{nsrv}SV_{nsrv} - \sum_i \sum_j \sum_k \sum_m X_{ijkm}XC_{ijkm} + \sum_n \sum_s \sum_q L_{nsq}LC_{nsq} - \sum_i W_i WC_i - \sum_i IB_i IC_i - \sum_n \sum_s \sum_t T_{nst}TC_{nst}.$$

A definition of these terms and subscripts follows the mathematical expression of the constraints.

Model Constraints

Constraints on the model include acreage of dry and irrigated land available for production of the endogenous crops, acre-feet of water available for use by endogenous crops and livestock, commodity balance rows, a national cotton demand equation, and the grid and constraint rows associated with the separable programming formulation of the demand equations. Mathematical expressions for each follow.

Dryland acreage by land class by producing area:

$$\sum_k \sum_m X_{ijkm}AD_{ijkm} \le DA_{ij}. \tag{4}$$

[1] Integration of (2) is possible only if B is symmetric. McCarl and Spreen discuss this requirement and suggest ways of relaxing this assumption.

[2] McCarl and Tice discuss the use of matrix diagonalization as a solution to this problem.

Irrigated land acreage by land class by producing area:

$$(5)\qquad \sum_k \sum_m X_{ijkm} AI_{ijkm} \le IA_{ij}.$$

Water availability by producing area:

$$(6)\quad \sum_j \sum_k \sum_m \sum_u X_{ijkm} W_{ijkmu} CWU_{iu} + \sum_n \sum_p \sum_q L_{nq} LWU_{nsq} LW_{ni} \le WS_i.$$

Endogenous crop commodity balance rows by demand region:

$$(7)\quad \sum_i \sum_j \sum_k \sum_m X_{ijkm}\, W_{ijkmu}\, CY_{ijkmsu} - Q_{ns} - \sum_t T_{nst} \ge CD_{ns}.$$

Endogenous livestock commodity balance rows by demand region:

$$(8)\qquad \sum_q LY_{nsq}\, L_{nsq} - Q_{ns} \ge LD_{ns}.$$

Cotton demand at the national level:

$$(9)\quad \sum_i \sum_j \sum_k \sum_m X_{ijkm}\, W_{ijkmu}\, CY_{ijkmu} \ge DC.$$

Subscripts in equations (3) through (9) refer to the following:

$n = 1, \ldots, 8$	for the demand regions;
$s = 1, \ldots, 6$	for the endogenous commodities;
$r = 1, \ldots, 6$	for the endogenous commodities;
$v = 1, \ldots, 10$	for the number of steps defined for each separable variable;
$i = 1, \ldots, 105$	for the producing areas;
$j = 1, \ldots, 10$	for the land quality classes;
$k = 1, \ldots, 330$	for the crop rotations;
$m = 1, \ldots, 12$	for the alternative conservation and tillage practices per rotation;
$q = 1, \ldots, 32$	for the livestock rations;
$t = 1, \ldots, 76$	for the transportation routes defined; and
$u = 1, \ldots, 10$	for the possible irrigated crops.

Variables in equations (3) through (9) are defined as follows:

A_{ns} is the linear demand coefficient for commodity s in region n;

Q_{ns} is the number of units of commodity s marketed in demand region n;

SV_{nsrv} is the separable variable step v, defined for each squared ($s = r$) and cross-product ($s \neq r$) term for commodities marketed in region n;

B_{nsrv} is the demand coefficient corresponding to step v of each of the squared and cross-product terms for commodities marketed in region n;

X_{ijkm} is the level of rotation k using conservation-tillage method m on land class j in producing area i;

XC_{ijkm} is the cost per acre of rotation k with conservation-tillage practice m in producing area i on land class j;

L_{nsq} is the number of units of livestock activity s receiving ration q in demand region n;

LC_{nsq} is the cost per unit of livestock activity s receiving ration q in demand region n;

W_i is the number of acre-feet of water purchased in producing area i;

WC_i is the cost per acre foot of water purchased in producing area i;

IB_i is the acre-feet of water transferred out of producing area i;

IC_i is the cost differential on a per acre foot basis for water in producing area i;

T_{nst} is the number of units of commodity s transported over route t from demand region n;

TC_{nst} is the cost per unit of commodity s transported over route t from demand region n;

AD_{ijkm} is the acres of dryland used per unit of rotation k using conservation-tillage method m on land class j in producing area i;

DA_{ij} is the acres of dryland available for endogenous crops on land class j in producing area i;

AI_{ijkm} is the acres of irrigated land used per unit of rotation k using conservation-tillage method m on land class j in producing area i;

IA_{ij} is the acres of irrigated land available on land class j in producing area i;

W_{ijkmu} is the rotation weight for crop u in rotation k using conservation-tillage method m on land class j in producing area i;

CWU_{iu} is the acre feet per acre water use coefficient for crop u in producing area i;

LWU_{nsq} is the acre feet per unit water use coefficient for livestock type s consuming ration q in market region n;

LW_{nsi} is the proportion of livestock type s from demand region n falling in producing area i;

WS_i is the acre feet of water available for use by the endogenous agricultural sector in producing area i;

CY_{ijkmsu} is the per acre production of commodity s from crop u in rotation k using conservation-tillage system m on land class j in producing area i;

CD_{ns} is the exogenously determined demand for commodity s in demand region n;

LY_{nsq} is the yield of commodity s from livestock activity q in demand region n;

LD_{ns} is the exogenously determined demand for livestock commodity s in demand region n;

CY_{ijkmu} is the per acre production of cotton in rotation k using conservation-tillage practice m on land class j in producing area i; and

DC is the exogenous national demand for cotton.

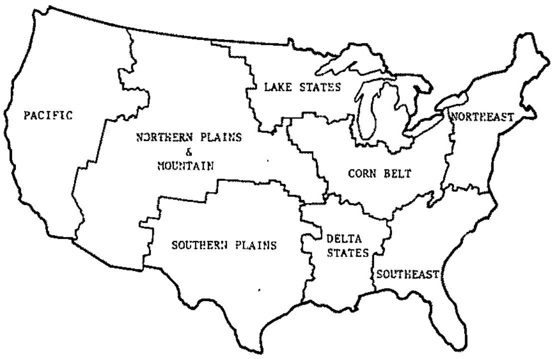


Figure 1. The eight demand regions

Regional Delineations

In order to represent the interregional competitive aspects of U.S. agriculture, the major constraints and demands on the agricultural production sector are formulated regionally. Three sets of regions are defined in the model: the crop production regions, the livestock production and market regions, and the endogenous demand regions.

Crop production activities and the land base are defined for 105 producing areas. The producing areas are derived from the Water Resource Council's 99 aggregated subareas (U.S. Water Resources Council). Water resources are defined for the producing areas corresponding to the 17 Great Plains, Mountain, Southwest, and Pacific states. Livestock production activities and the exogenous commodity demands and exports are defined for 28 market regions. The market regions are aggregations of contiguous producing areas.

The eight endogenous demand regions of figure 1 are aggregations of contiguous market regions. Each demand region is the demand and transportation center for the endogenous commodities. Metropolitan centers in each region form the model's transportation sector.

Major Sectors of the Model

A brief description of each of the major components of the model follows. Additional information about the model specification and formulation is available from the authors.

Demand Sector

The demand sector consists of three categories: (*a*) demands for endogenous commodities for which equations are specified, (*b*) fixed demand for the endogenous crop, cotton, and (*c*) demands for exogenous commodities. Each of the three demand categories incorporates net export, domestic consumption, and intermediate uses.

The fixed demands for cotton, the exogenous crops, and projected net exports are 1985 government projections (Quance, Smith, Powell). Adjustments were made in the model's resource base for the quantities of land, water, nitrogen, and feedstuffs either utilized or produced by the exogenous crops.

Land Base

The cropland base is derived from the Conservation Needs Inventory (CNI), which reports acres of land by use and agricultural capability class (Conservation Needs Inventory Committee). The CNI county acreages are aggregated for dryland and irrigated uses into the 105 producing areas and into 5 quality classes. The 5 quality classes are aggregations of the 29 CNI agricultural capability classes and subclasses. The CNI capability class and subclass distinctions are based on the relative suitability of the land for agricultural production purposes. The projected 1985 land base is derived from the original CNI by adjusting for projected wetland drainage, irrigation development, and conversions to urban and other nonagricultural uses by 1985 (Meister and Nicol).

Crop Production Sector

The crop sector contains barley, corn, corn silage, cotton, legume hay, nonlegume hay, oats, sorghum, sorghum silage, soybeans, and

wheat. Unique production activities are defined for each of five land quality classes in each of the 105 producing areas. Each crop management activity consists of a rotation, a tillage and conservation practice, and irrigated or dryland farming utilizing the nitrogen, land, and water resources available. Crop production costs include machinery, labor, pesticide, and miscellaneous costs. These costs were developed using the U.S. Department of Agriculture's (USDA) Firm Enterprise Data System (FEDS) crop budget generator.

Gross soil loss as calculated in the model represents the average annual tons of soil leaving the field. This measurement of soil loss does not represent the amount reaching streams or bodies of water. Two separate procedures were used to determine gross soil loss per acre. For the areas east of the Rocky Mountains, the "Universal Soil Loss Equation" was used (Wischmeier and Smith). For areas west of the Rocky Mountains, soil loss coefficients for each management system were derived from a Soil Conservation Service questionnaire.

Livestock Sector

The livestock sector consists of beef cows, feeders, dairy, and hogs. Several alternative rations, reflecting optimum input ratios for alternative output levels and price ratios are specified for each type of livestock. Activity costs include all production costs except feed, which is endogenously determined. Nitrogen in livestock manure is a source of fertilizer to the crop sector (Short and Dvoskin).

Water Sector

The water sector defines water supplies in the western United States. Dependable supplies of both surface and ground water are defined (Colette). Water prices are acreage-weighted, average reimbursable costs of the Bureau of Reclamation water projects. Water transportation activities are defined reflecting both natural and manmade flows.

Transportation Sector

Interregional interdependence is introduced through the transportation sector. Transportation routes are defined between all contiguous regions. Transportation costs are based on 1975 rail rates for grains and truck rates for livestock commodities using the mileage between the metropolitan centers of the demand regions.

Policy Alternatives

Four alternative combinations of supply control and soil conservation policies are analyzed to test their impact on regional farm prices and incomes, farm output, farm input use, and gross soil erosion. The four policy alternatives consist of a baseline (Alternative A); a maximum allowable per acre soil loss equal to the soil tolerance levels (Alternative B); a 10% land retirement, supply control policy designed without special conservation aspects (Alternative C); and a 40% land retirement policy designed as a simultaneous supply control mechanism and soil conservation program (Alternative D).

Alternative A is based on a projection to 1985 of baseline demands and export levels in the absence of land retirement or soil loss policies. Alternative B represents a soil conservation policy apart from supply control or land retirement. Under Alternative B, crop production activities whose estimated per acre gross soil losses exceed the established soil tolerance levels are restricted from entering the solution. The soil loss tolerance levels reflect the maximum yearly allowable soil loss consistent with maintaining economically indefinite productive capacity of the soil (Wischmeier and Smith). Soil tolerance levels range from one to five tons per acre per year depending upon soil properties, topography, and prior erosion.

Alternatives C and D represent two alternative land retirement or supply control policies. Alternative C assumes that 10% of all endogenous cropland is retired from production. The 10% reduction is distributed evenly across all land classes and regions. Hence, all farmers and regions would be treated similarly with respect to land retirement. Alternative D assumes that 40% of the cropland in the Conservation Needs Inventory quality classes, III_e, IV_e, VI, VII, and VIII is retired from production. Alternative D thus incorporates components of both supply control and soil conservation into a single policy concentrating land retirement in regions or locations where land is most erosive.

Results

This programming model is designed for normative planning and impact analysis rather than positive prediction. As such, comparisons between alternative solutions of the model can be more valid and useful than comparisons with current actual values. However, it is informative to compare the baseline model results with current values in order to provide some indication of the "realism" of the basic model structure.

Alternative A is a normative benchmark for comparisons with the policy alternatives. It reflects baseline projections of moderate or trend level estimates of population, per capita consumption, and exports. In addition, agriculture is assumed to operate under perfectly competitive conditions without explicit policies designed to increase farm income or reduce soil erosion.

Table 1 presents a regional comparison of some of the model's key baseline results with 1977 actual values. The regional distribution of crop acres in the baseline model closely approximates the 1977 actual distribution. The largest variation in acreage is only 1.2% in the Corn Belt. With the exception of the Delta States, the baseline model consistently overstates per acre soil losses relative to the 1977 Erosion Inventory estimates. The primary reason is that the model chooses the profit-maximizing combinations of rotation, conservation practice, and tillage practice, but, in reality, some erosive land already has been terraced and many farmers follow sound conservation practices as a matter of principle. The regional income comparisons exhibit the most variation and are the least reliable of the three data items. Nationally, the baseline estimate of net farm income is nearly identical to the 1977 actual figure. However, the model structure does not allow estimation of regional net farm income. Instead, only net farm returns from endogenous crops are available regionally.

Policy alternatives B, C, and D each reflect a different approach toward the dual goals of increasing farm income and conserving soil. Alternative B was formulated with the singular policy objective of conserving soil, Alternative C with the sole policy objective of increasing farm income, and Alternative D with the dual objectives of increasing farm income and con-

Table 1. Comparison of 1977 Actual with Baseline Estimates of Endogenous Crop Acreage, Soil Loss, and Net Farm Income

	Endogenous Crop Acres[a]		Endogenous Soil Loss[b]		Net Farm Income[c]	
Demand Region	1977 Actual[b]	Baseline	1977 Actual[e]	Baseline	1977 Actual[f]	Baseline
Northeast	13.5	11.9	104.3	116.2	547.1	418
	(4.0)	(3.3)	(7.8)	(9.8)	(1.8)	(3.2)
Southeast	16.0	18.3	172.7	263.3	1039.2	571
	(4.7)	(5.1)	(10.8)	(14.4)	(3.5)	(4.4)
Lake States	62.2	66.5	209.8	270.7	4078.1	1277
	(19.1)	(18.6)	(3.3)	(4.1)	(13.8)	(9.9)
Corn Belt	71.2	71.5	581.3	792.6	8991.1	2979
	(21.2)	(20.0)	(8.2)	(11.1)	(30.4)	(23.0)
Delta States	29.9	25.0	421.2	347.5	3047.6	325
	(7.7)	(7.0)	(16.2)	(13.9)	(10.3)	(2.5)
Northern Plains	73.8	80.9	517.9	685.8	5051.2	2413
	(21.9)	(22.6)	(7.0)	(8.5)	(17.1)	(18.6)
Southern Plains	54.0	61.3	263.9	548.9	4459.5	4428
	(16.0)	(17.1)	(4.9)	(9.0)	(15.1)	(34.2)
Pacific	17.8	22.4	35.3	74.9	2391.7	550
	(5.3)	(6.3)	(2.0)	(3.3)	(8.1)	(4.2)
United States	336.3	357.8	2306.3	3099.8	29605.5	12961[g]
	(100.0)	(100.0)	(6.9)	(8.7)	(100.0)	(100.0)

[a] Acres of barley, corn, cotton, hay, oats, sorghum, soybeans, and wheat in millions of acres, percentage of U.S. total in parentheses.
[b] Soil losses from endogenous crop production in millions of tons, tons per acre in parentheses.
[c] 1977 actual figures are total net farm income. The baseline figures are estimated net farm returns from endogenous crops. Both columns are millions of dollars, percentage of U.S. total in parentheses.
[d] USDA, *Crop Production 1978 Annual Summary.*
[e] SCS
[f] USDA, *State Farm Income Statistics.*
[g] Estimated total U.S. net farm income in the baseline model is $29,206 million.

serving soil. Consequently, the alternatives have quite different impacts on the degree of soil conservation and the increased income generated.

With Alternative B, the soil loss limit results in a 68% decline in both total and per acre gross soil erosion arising from endogenous crop production relative to A (table 2). Table 2 also indicates that both total and per acre erosion losses are reduced substantially in all regions. This result is precisely what should be expected from such a policy. However, a second less obvious result of the soil loss policy is that net farm income increases by 8% relative to the baseline (table 3). The increased income results from the decline in output when soil loss restrictions are imposed, coupled with the inelastic commodity demands.

Regional net farm returns from the endogenous crops are reported in table 4. The soil conservation policy, Alternative B, has the least impact of any of the alternatives analyzed. With the exception of the Northeast, no region's share of net returns from the endogenous crops varies by more than 2% of the base. A shifting of endogenous crops out of the Northeast region, coupled with the increased cost of production incurred in response to the soil loss restrictions, results in the relatively large decline in endogenous net returns in the Northeast.

The reductions in gross soil loss with Alternative B were achieved by reducing the row crop intensity, increasing the use of conservation practices (contouring, strip cropping, and terracing), and increasing reduced tillage prac-

Table 2. Estimated Soil Loss from Endogenous Cropped Acres by Demand Region for the Four Model Alternatives

	Model Alternatives							
	A		B		C		D	
Demand Region	Million Tons	Tons per Acre	Million Tons	Tons per Acre	Million Tons	Tons per Acre	Million Tons	Tons per Acre
Northeast	116.2	9.8	30.7	2.6	114.8	10.3	95.8	8.8
Southeast	263.3	14.4	54.5	3.0	209.8	12.7	201.1	11.9
Lake States	270.7	4.1	221.4	3.2	316.9	5.1	278.4	4.3
Corn Belt	279.6	11.1	204.5	2.9	673.3	10.2	622.5	9.3
Delta States	347.5	13.9	75.4	3.1	384.5	16.6	388.3	16.1
Northern Plains	685.8	8.5	185.8	2.3	737.0	9.6	559.7	8.1
Southern Plains	548.9	9.0	157.8	2.5	474.0	8.2	425.7	7.8
Pacific	74.9	3.3	36.4	1.6	52.0	2.5	40.8	2.1
United States	3099.8	8.7	996.6	2.7	2962.2	8.9	2612.4	8.0

Table 3. Estimates of Net Farm Income for Each of the Four Model Alternatives

	Model Alternatives			
	A	B	C	D
	($ Million)			
Endogenous cash receipts	71,661	76,723	82,709	81,341
Exogenous cash receipts[a]	27,046	27,046	27,046	27,046
Total cash receipts	97,707	103,769	109,744	108,387
Endogenous production expenses[b]	48,780	51,373	57,431	55,749
Exogenous production expenses[c]	29,892	29,892	29,892	29,892
Total production expenses	78,672	81,265	27,323	85,641
Net farm returns	20,035	22,504	22,432	22,746
Nonmoney income and inventory change[d]	9,171	9,171	9,171	9,171
Income from government payments	—	—	2,057	1,556
Total net farm income	29,206	31,675	33,660	33,483

[a] 1977 cash receipts for exogenous commodities reported in 1975 dollars.
[b] Expenses determined endogenous to the model.
[c] Other production expenses including $9920 for expenses related to the endogenous commodities and $19,972 pertaining to exogenous commodities.
[d] The 1977 level of nonmoney income is reported in 1975 dollars.

Table 4. Estimates of Regional Net Farm Returns from the Endogenous Commodities for Each of the Model Alternatives

	Model Alternatives							
	A		B		C		D	
Demand Region	Value[a]	Percent[b]	Value	Percent	Value	Percent	Value	Percent
Northeast	418	3.2	111	.7	147	1.0	155	1.0
Southeast	571	4.4	838	5.4	915	6.0	807	5.1
Lake States	1277	9.9	1354	8.8	1349	8.8	1416	9.0
Corn Belt	2979	23.0	3810	24.6	5435	35.4	5586	35.6
Delta States	325	2.5	478	3.1	831	5.4	862	5.5
Northern Plains	2413	18.6	2797	18.1	2983	19.4	2863	18.3
Southern Plains	4428	34.2	5556	35.9	3533	23.0	3799	24.2
Pacific	550	4.2	515	3.3	166	1.1	186	1.2
United States	$12961	100.0	15459	100.0	15359	100.0	15673	100.0

[a] Values are in millions of 1975 dollars.
[b] Percentage of U.S. total by region.

tices. However, the reductions in gross soil loss were achieved by increasing total and per acre use of chemical pesticides and fertilizers, table 5. As a result of this substitution of chemical for mechanical inputs, part of the environmental improvements associated with less soil erosion may be offset.

Under Alternative C, 37 million acres, or 10% of the endogenous cropland, is retired from production (table 6). This figure was selected so that endogenous prices increased to a level approximating 1979 target prices. As a result, net farm income increased 15% over the base level. This increase was the sole objective of Alternative C. Alternative D, on the other hand, was designed to achieve a net farm income increase equivalent to that obtained under C, while simultaneously trying to reduce gross soil erosion as much as possible through the sole use of land retirement. The objectives of Alternative D were achieved by retiring 45 million acres of the most erosive cropland (table 6). Because the land retired under D is less productive than under C, both per acre and total set-aside payments are significantly lower in D (table 6).

Regionally, Alternative C and D have quite similar effects on the distribution of net farm returns (table 4). Regional shares increase in the Southeast, Corn Belt, and Delta States regions and decline in the Northeast, Lake States, Southern Plains, and Pacific regions under both C and D. The largest increase occurs in the Corn Belt, where the share of national net farm returns increases by over 12% in Alternatives C and D relative to A. The largest decline occurs in the Southern Plains, where that region's share of returns declines by over 10% in both C and D relative to A.

The retirement of 45 million acres of erosive lands under Alternative D not only achieved the specified 15% increase in net farm income, but also resulted in 16% less gross soil loss compared to the base (table 2). This reduction

Table 5. Relative Total and Per Acre Usage of Purchased Inputs in Producing the Endogenous Commodities for Each of the Model Alternatives

	Model Alternatives							
	A		B		C		D	
Input	Total	Per Acre	Total	Per Acre	Total	Per Acre	Total	Per Acre
Labor	100	100	104	102	102	106	101	106
Pesticides	100	100	123	121	121	126	111	117
Nitrogen fertilizer	100	100	116	114	126	131	117	123
Other fertilizer	100	100	109	107	105	109	102	107
Machinery	100	100	108	106	106	110	104	109
Total[a]	100	100	107	105	105	109	103	108

[a] Includes other fixed and miscellanous expenses.

Table 6. Estimated Acres Set-Aside, Total Set-Aside Payments, and Per Acre Set-Aside Payments by Demand Region for Model Alternatives C and D

	Alternative C			Alternative D		
Demand Region	Acres Retired	Total Payments[a]	Per Acre Payments[b]	Acres Retired	Total Payments[a]	Per Acre Payments[b]
	(thousands)	($million)	($)	(thousands)	($million)	($)
Northeast	1,249	99	79	1,500	76	51
Southeast	1,902	103	54	1,638	54	33
Lake States	6,993	304	43	4,546	153	34
Corn Belt	7,340	596	81	6,564	381	58
Delta States	2,614	148	57	1,633	62	38
Northern Plains	8,619	372	43	16,138	430	27
Southern Plains	6,442	295	46	9,449	271	29
Pacific	2,345	140	60	3,713	129	35
United States	37,504	2,057	55	45,181	1,556	34

[a] Total payments equal acres retired multiplied by the per acre payments.
[b] Per acre payments equal the average of the land shadow prices in the baseline and corresponding set-aside alternative.

in erosion is less than might be expected for two reasons. First, much of the land formally retired in Alternative D was already essentially idle in the base line model. Second, increased production intensity causes greater per acre soil losses on the land remaining in production. Alternative C, on the other hand, had little impact on either total or per acre erosion nationally.

Both land retirement policies had substantial impacts on regional soil losses. Under C, significant reductions in total soil losses in the Northeast, Southeast, Southern Plains, and Pacific regions were offset by equally significant increases in soil losses in the Lake States, Corn Belt, Delta States, and North Plains regions (table 2). Under D, soil loss reductions were larger and occurred more consistently than under C. The only significant exception was the Delta States region, which experiences a 12% increase in total soil erosion in D relative to the base.

The larger income generated in Alternative C and D results from increased prices associated with a shift in aggregate product supply functions. The actual decreases in production in C and D compared to A are relatively moderate for two reasons. The first is the inelastic nature of the demand for agricultural commodities The second is that purchased inputs (labor, chemicals, and machinery) substitute for the land input in the production process. For example, total purchased input use in C and D increases approximately 4% and per acre use nearly 9% (table 5) relative to A. The largest increases occur in chemical inputs (pesticides and fertilizers). Alternative D not only results in significantly less soil erosion than Alternative C but also in significantly less use of chemical inputs.

The distribution of the burden (cost) of policies designed to increase farm income and conserve soil varies. In each of the three alternatives analyzed, a substantial portion of the burden (cost) is shifted onto consumers in higher prices. However, as usual, part is borne by producers, and this varies by region and producer type.

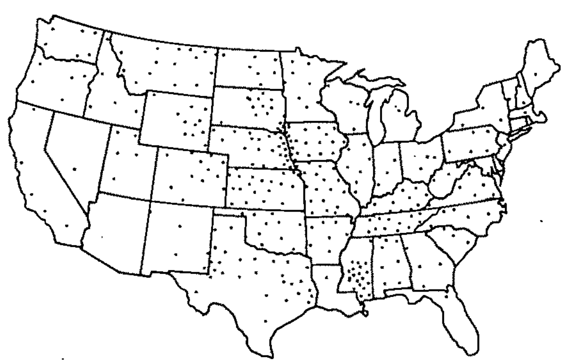
In Alternative B, the soil conservation alternative, producers are forced to limit gross soil erosion to a maximum related to the soil tolerance level. The soil tolerance level is a function of the depth of the topsoil, its productivity, and rate of new soil generation. The estimated rates of soil erosion are a function of topography, rainfall, soil type, and farming practices. Because the rate of new soil generation is relatively constant from one region to the next, and because the thinner the layer of topsoil the lower the soil tolerance level, some regions are affected much more by the soil loss restriction of Alternative B than others. Erosive areas not only display greater erosion rates but also tend to have lower soil tolerance limits because of prior erosion. Thus, meeting the soil tolerance limit in more erosive areas may require substantial adjustments in crops grown, tillage practices employed, and conservation practices used. In other, less erosive areas little, if any, adjustments are required to reduce losses below tolerance levels. Thus, the burden of Alternative B is borne most heavily by producers in the more erosive areas of the nation. The location of land idled under

the soil tolerance level soil loss limits is illustrated in figure 2.

The burden of the 10% homogenous land retirement policy (Alternative C) nationally is distributed more evenly than under B. In C, cropland is retired homogenously across all quality classes and regions; thus, all producers and all regions are affected equally on a percentage basis. In contrast to C, the burden of the 40% conservation land retirement is concentrated exclusively on producers and regions with less productive and more erosive lands (figure 3).

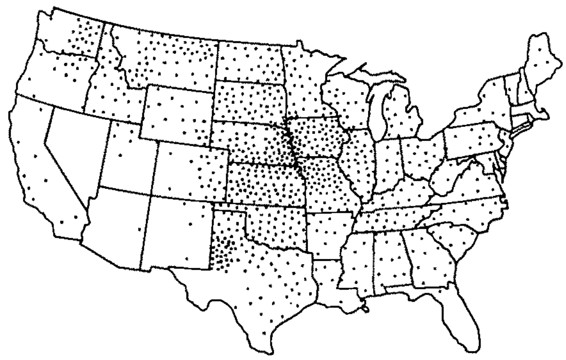
Other Considerations

Retirement of cropland and adjustments in conservation and tillage practices affect the labor and capital requirements of producers. As cropland is retired, the land-labor-capital ratios are significantly changed. Theoretically, if the land-labor-capital ratio was optimal prior to the land retirement and input prices remain constant, labor and capital should transfer out of erosive areas in response to the reduction in land input. However, restrictions on the use of erosive land will also lead to increased rents for less erosive lands. The increased cost of land remaining in production relative to capital and labor encourages the substitution of capital and labor for land or a shift to more intensive production on the land remaining in production. The net effect of these forces in the alternatives analyzed in this study is an increase in capital and labor employed in agriculture (table 5). The problem that is not addressed is the transfer within agriculture. The magnitude and the difficulty of achieving this transfer depends upon the particular form



Each dot = 50,000 acres

Figure 2. Location of idle cropland in the soil conservation alternative (Alternative B)



Each dot = 500,000 acres

Figure 3. Location of idle cropland in the conservation land retirement alternative (Alternative D)

of the policy. Issues that affect this transfer include whether the policy is short- or long-term, whether there is partial or whole farm retirement, and the opportunity returns available for labor and capital.

Another issue is the potential impact of this capital and labor transfer on rural communities. Many rural communities depend on providing services and inputs for the local farm sector. Whole farm retirement in erosive areas, for example, could have severe ramifications for the nonfarm sector of communities.

No estimate was made of the administrative or enforcement costs of the various policies. The costs of inventorying land, measuring soil erosion, enforcing compliance, etc., could be extremely large unless efficient administrative methods are developed. This area needs additional research, especially since Section 208 of the 1972 Federal Water Pollution Control Act Amendments requires states to develop plans for controlling nonpoint pollution from agriculture and silvaculture.

Throughout, this study concentrated on gross soil erosion and application rates of fertilizers and chemicals rather than on direct measures of environmental quality. There are two reasons for this approach. First, soil conservation is an important objective in itself. Second, national information needed to relate gross soil erosion and rates of chemical applications directly to measures of environmental quality is currently unavailable.

Conclusions

This study indicates that a conservation-oriented land retirement policy can be de-

signed to achieve an increase in net farm income equivalent to the traditional type of general land retirement, while simultaneously achieving a significant reduction in gross soil erosion. In addition, these results can be obtained with fewer chemical inputs and a significantly smaller direct program cost for the government. More important perhaps is that the analysis demonstrates the economic potential of analyzing and coordinating various agricultural policies and policy combinations.

The separable programming model utilized in this study provides a flexible and useful tool for policy analysis. It yields much information of the type and detail necessary for effective planning. The results, however, need to be interpreted in relation to the strengths and limitations of the model. The model is a normative, comparative static, mathematical programming model with all its standard limiting assumptions. In addition, its sheer size — while the source of much of its usefulness, flexibility, and capacity — presents significant data and programming requirements. Finally, as always, the results can be no better than data on which they are based.

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Net Investment in Farm Tractors: An Econometric Analysis

John B. Penson, Jr., Robert F. J. Romain, and Dean W. Hughes

A wide range of assumptions about the capital deterioration and marginal factor cost of tractors has been made in previous studies. This study develops a measure of the implicit rental price of tractors which accounts for the capital structure used by farmers, the capacity depreciation of tractors, and income tax considerations. Estimates of net investment models for alternative capacity depreciation patterns are compared to those suggested by engineering considerations. The results show that the frequently used geometric decay pattern does the poorest job of explaining annual real net investment in farm tractors.

Key words: capacity depreciation, implicit rental price, real net investment.

There were numerous econometric studies of aggregate investment behavior in the U.S. farm sector conducted during the 1950s and 1960s. While these studies investigated a wide range of durable inputs, the input receiving the most attention was farm tractors. Several questionable assumptions in these studies, however, have a direct bearing on the specification, measurement, and estimation of their statistical models. For example, each study had to assume how the productive capacity of farm tractors depreciates over their service lives since the actual capacity depreciation pattern is not known. Cromarty assumed the productive capacity of a tractor is much like that of a light bulb; it does not decline at all until the final year of its service life. Heady and Tweeten assumed farm tractors wear out in a geometric decay fashion. Finally, Griliches examined the difference between the regression estimates based upon these two capacity depreciation patterns, concluding that "the truth may lie somewhere in between these two extremes" (p. 202). The productive capacity of the stock of tractors on farms in these studies differs sharply from that reported by Penson, Hughes, and Nelson, who estimated a capacity depreciation pattern for tractors based upon engineering data. Their estimated pattern fell in between the pattern assumed by Cromarty and the pattern assumed by Heady and Tweeten, as Griliches supposed. It was also concave rather than convex, as suggested by the geometric decay pattern. This leads to large differences in the annual data for net investment and the existing capital stock, as Penson, Hughes, and Nelson show.

Measures of the marginal factor cost of tractors in previous studies did not include all the investment costs suggested by maximization of the present value of owner equity. Cromarty considered only the purchase price of the farm tractor. Griliches included both the purchase price and the nominal interest rate. All, however, appear to have ignored the real after-tax cost of borrowing, investment tax credit, tax depreciation allowances, and the real after-tax cost of owner equity capital.

The purpose of this paper is to develop and test an econometric model of annual real net investment in farm tractors. The implicit rental price of capital advanced by Coen is modified to reflect the capital structure farmers follow when financing purchases of durable inputs. Emphasis is placed on determining which of the frequently assumed capacity depreciation patterns most closely approximates the statistical estimates based on the engineering data pattern developed by Penson, Hughes, and Nelson.

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Determinants of Net Investment

The aggregate investment behavior model used here was developed initially from the

theory of the firm in continuous equilibrium. Conditions of perfect competition and knowledge were assumed. Then, recognizing that perfect knowledge does not exist and lags in investment response do, the model was modified to include the adaptive expectations and partial adjustment hypotheses.

Desired Stock of Farm Tractors

If, when making investment decisions, farmers maximize the present value of equity, they would continue to add to their existing stock of plant and equipment as long as the present value of the periodic net cash flows generated by an additional unit exceeds the net purchase price of the input. For tractors, this can be stated algebraically as follows:

$$(1)\quad \sum_{t=1}^{\infty} [p(\partial X/\partial K_j^T) - (\partial T_t/\partial K_j^T) - r(\partial D/\partial K_j^T) - (\partial P/\partial K_j^T)]\,(1+\rho)^{-t} > q^T(\alpha - i_c)[1 + \sum_{t=1}^{\infty} (\partial R_{jt}^T/\partial K_j^T)(1+\rho)^{-t}],$$

where

$$(2)\quad (\partial T_t/\partial K_j^T) = i_\pi\{p(\partial X/\partial K_j^T) - r(\partial D/\partial K_j^T) - q^T[\delta(1-\delta)^{t-1} + \sum_{i=1}^{t} \delta(1-\delta)^{i-1}(\partial R_{jt-i}^T/\partial K_j^T)]\},$$

and where p represents the real price farmers receive per unit of output, X is the real value of farm output, K_j^T is the real stock of farm tractors measured according to the jth capacity depreciation pattern, T_t is the income taxes paid in period t expressed in constant dollars, r is the real rate of interest on debt capital, D represents debt outstanding, P is the principal payment expressed in constant dollars, ρ is the real after-tax opportunity rate of return on equity capital desired by farmers, q^T is the real price paid for farm tractors at the retail level, α is the proportion of the investment financed with equity capital, i_c is the investment tax credit rate, R_{jt}^T represents the real level of replacement investment required in period t according to the jth capacity depreciation pattern, i_π is the income tax rate, and δ represents the tax depreciation rate given by $2/n$, where n is the service life of the tractor.

The first term on the left-hand side of equation (1) is the real marginal net revenue excluding interest payments associated with financing a new tractor. The second term is the increase in income taxes expressed in constant dollars, while the third and fourth terms are the interest and principal payments associated with the loan on the investment, respectively. The right-hand side is the initial cash outflow—down payment minus the investment tax credit—plus the present value of all future cash outflows necessary to maintain the capital stock at its new level. Equation (2) gives the increase in income taxes generated by a new tractor—marginal net revenue minus interest payments and tax depreciation allowances on the new unit and its replacements, all multiplied by the income tax rate.

Both the principal and interest payments $[r(\partial D/\partial K_j^T)$ and $(\partial P/\partial K_j^T)]$ are constant over time because of our assumption that all future replacement investments necessary to maintain the capital stock at its new level are financed the same way as the original investment. We also assume the length of the loan period is the same as the service life of the tractor and that farmers expect real prices (p), real interest rates (r), and the marginal physical product of tractors $(\partial X/\partial K_j^T)$ to remain at current levels. These last two assumptions are similar to Coen's. All three allow us to treat components of equation (1) as consols, greatly simplifying the analysis.

Maximization of the present value of owner equity under the conditions assumed above, according to Coen, requires that

$$(3)\qquad (\partial X/\partial K_j^T) = c_j^T/p,$$

where c_j^T is the implicit rental price of tractors associated with the jth capacity depreciation pattern. Assume that farm output is produced according to the production function,

$$(4)\qquad X = AL^{\phi}(K_j^T)^{\beta}(K_j^o)^{\gamma}(K^{\ell})^{\omega}(K^{v})^{\epsilon},$$

where L represents the labor input, K_j^T represents the real stock of tractors measured according to the jth capacity depreciation pattern, K_j^o represents the real stock of other durable inputs measured according to the jth capacity depreciation pattern, K^{ℓ} represents land, K^v represents the variable production inputs used to produce farm output, and ϕ, β, γ, ω, and ϵ are partial production elasticities associated with L, K_j^T, K_j^o, K^{ℓ}, and K^v, respectively.[1] This, of course, means that the margi-

[1] The real productive value of the existing stock of farm tractors measured according to the jth capacity depreciation pattern is defined later in equation (14). As $\Sigma_k \xi_i$ in that equation approaches 1.0, the remaining fraction of the original productive capacity of tractors purchased in year $t-k$ approaches zero.

nal physical product for tractors is

$$(5) \qquad (\partial X/\partial K_j^\tau) = \beta(X/K_j^\tau).$$

Substituting equation (5) into equation (3), we see that the desired stock of tractors, according to the jth capacity depreciation pattern, would be

$$(6) \qquad K_j^{\tau *} = \beta(pX/c_j^\tau)^*,$$

where c_j^τ represents the implicit rental price of tractors associated with the jth capacity depreciation pattern. Equation (6) implies that the desired stock of tractors is positively affected by expected real gross income from farming and negatively affected by the expected implicit rental price for tractors. Similar equations also could be developed for other inputs in equation (4).

Implicit Rental Price of Tractors

A recent innovation in aggregate investment behavior analysis is the concept of the implicit rental price of capital. Coen has advanced this concept in studies of aggregate investment behavior in the U.S. manufacturing sector. An appealing feature of Coen's work is his explicit accounting of the effects that alternative capacity depreciation patterns have upon marginal factor costs of durable inputs. Coen, however, ignores debt financing and the deductibility of interest payments. In the farm sector, where the use of debt capital relative to owner equity rose dramatically during the 1970s, such an omission could seriously understate the implicit rental price of tractors (Penson).

To measure the implicit rental price of capital, accounting for both debt and owner equity financing of capital expenditures, we must solve initially for the marginal value product of tractors. Substituting equation (2) into equation (1) and solving for $p(\partial X/\partial K_j^\tau)$, we see that

$$(7) \quad p(\partial X/\partial K_j^\tau) = \frac{1}{(1 + i_\pi)} \Bigg[\Bigg\{\rho q^\tau(\alpha - i_c)\Bigg[1 + \sum_{t=1}^{\infty} (\partial R_{jt}^\tau/\partial K_j^\tau)(1 + \rho)^{-t}\Bigg]\Bigg\} - q^\tau i_\pi \Bigg\{\sum_{t=1}^{\infty} \delta(1 - \delta)^{i-1}(1 + \rho)^{-t} + \sum_{t=1}^{\infty} \Bigg[\sum_{i=1}^{t} \delta(1 - \delta)^{i-1}(\partial R_{jt-i}^\tau/\partial K_j^\tau)\Bigg] (1 + \rho)^{-t}\Bigg\} + Z - i_\pi r\psi\Bigg],$$

where Z represents the value of the periodic loan payment (principal plus interest) and ψ is the fraction of the purchase price financed with debt capital (i.e., $\psi = 1 - \alpha$).

Multiplying both sides of equation (3) by p and substituting the right-hand side of equation (7) into the resulting equation, it can be shown that

$$(8) \quad c_j^\tau = [(q^\tau\rho)/(1 - F_j)] [\alpha - i_c - i_\pi\{\delta/(\delta + \rho)\}]/(1 - i_\pi) + (Z - i_\pi r\psi)/(1 - i_\pi),$$

where

$$(9) \qquad F_j = \sum_{i=1}^{\infty} h_{ji}(1 + \rho)^{-i},$$

$$(10) \quad 1/(1 - F_j) = 1 + \sum_{t=1}^{\infty} (\partial R_{jt}^\tau/\partial K_j^\tau)(1 + \rho)^{-t},$$

$$(11) \quad \delta/(\delta + \rho) = \sum_{t=1}^{\infty} \delta(1 - \delta)^{t-1}(1 + \rho)^{-t},$$

and where F_j is the present value of the stream of capacity depreciation of a tractor associated with the jth capacity depreciation pattern and h_{ji} is the fraction of the tractor's original productive capacity lost in the ith year of its service life according to the jth capacity depreciation pattern. Equation (8) suggests that the implicit rental price of tractors will increase if their purchase price, the cost of debt and equity capital, capacity depreciation, or income tax rates increase. These effects will be offset to some extent by an increase in the investment tax credit rate and the deductibility of tax depreciation allowances and interest payments. The implicit rental price of tractors presented in equation (8) is a sharp contrast to the measures of the marginal factor cost specified in previous studies.

Desired Net Investment in Tractors

Annual gross investment for any durable input can be partitioned into replacement investment and net investment. Replacement at the sector level is the expenditure required to restore losses in the productive capacity of the existing capital stock, while net investment is the expenditure to expand the existing stock. More explicitly, net investment in tractors,

measured according to the jth capacity depreciation pattern, is

$$(12)\quad N_{jt}^{\tau} = K_{jt+1}^{\tau} - K_{jt}^{\tau} = I_t^{\tau} - R_{jt}^{\tau},$$

where

$$(13)\quad R_{jt}^{\tau} = \sum_{k=0}^{\infty} h_{jk+1} I_{t-k}^{\tau},$$

$$(14)\quad K_{jt}^{\tau} = \sum_{k=1}^{\infty} (1 - \sum_{i=1}^{k} h_{ji})\, I_{t-k}^{\tau},$$

and I_t^{τ} represents the level of real gross investment in tractors during the year, R_{jt}^{τ} is the real replacement investment needed according to the jth capacity depreciation pattern, and h_{ji} is the fraction of the tractor's original capacity lost in the ith year of its service life. Equation (12) states that the net expansion of farm tractor capacity is equal to the net change in the real productive value of the stock of tractors between successive accounting dates. This equation assumes that tractors are originally purchased at the beginning of the year and, therefore, depreciate by a factor of h_{ji} in their first period of ownership.

Substituting equation (6) into equation (12), we can show that if the adjustment from actual to desired stocks is completed within time period t, the desired expansion of farm tractor capacity is given by

$$(15)\quad N_{jt}^{\tau *} = \beta(pX/c_j^{\tau})_t^{*} - K_{jt}^{\tau}.$$

The amount of time necessary to adjust from current to desired stocks, however, may be longer than one period, due to institutional rigidities and other factors, Also, little is known about how farmers form expectations about the value of farm output and the implicit rental price of durable inputs.

Statistical and Measurement Procedures

The approach taken in this study to account for the adjustment to desired stocks and the formation of expectations by farmers is to utilize the compound geometric lag model described by Kmenta.

Statistical Model

The relationship between the desired stock of tractors and current real net investment, measured according to the jth capacity depreciation pattern, is

$$(16)\quad N_{jt}^{\tau} = \Theta_j^{\tau}(K_{jt+1}^{\tau *} - K_{jt}^{\tau}),$$

where $0 < \Theta_j^{\tau} \leq 1$, and Θ_j^{τ} represents the partial adjustment coefficient that describes the speed of adjustment of actual stocks to desired levels measured according to the jth capacity depreciation pattern. If $\Theta_j^{\tau} = 1$, then $N_{jt}^{\tau} = N_{jt}^{\tau *}$. Substituting equation (6) into equation (16), we see that

$$(17)\quad N_{jt}^{\tau} = \Theta_j^{\tau}\beta(pX/c_j^{\tau})_t^{*} - \Theta_j^{\tau}K_{jt}^{\tau}.$$

If we further assume an adaptive expectations hypothesis of the form

$$(18)\quad (pX/c_j^{\tau})_t^{*} - (pX/c_j^{\tau})_{t-1}^{*} = \lambda_j^{\tau}[(pX/c_j^{\tau})_t - (pX/c_j^{\tau})_{t-1}^{*}],$$

where $0 < \lambda_j^{\tau} \leq 1$, and λ_j^{τ} is the adaptive expectations coefficient, then the estimating equation would be

$$(19)\quad N_{jt}^{\tau} = \Theta_j^{\tau}\beta\lambda_j^{\tau}(pX/c_j^{\tau})_t + (1 - \lambda_j^{\tau})\, N_{jt-1}^{\tau} + \Theta_j^{\tau}(1 - \lambda_j^{\tau})K_{jt-1}^{\tau} - \Theta_j^{\tau}K_{jt}^{\tau} + \mu_t.$$

Since K_{jt-1}^{τ} is, by definition, equal to $K_{jt}^{\tau} - N_{jt-1}^{\tau}$, equation (19) reduces to

$$(20)\quad N_{jt}^{\tau} = b_0 + b_1(pX/c_j^{\tau})_t + b_2K_{jt}^{\tau} + b_3N_{jt-1}^{\tau} + \mu_t,$$

where $b_1 = \Theta_j^{\tau}\beta\lambda_j^{\tau}$, $b_2 = -\Theta_j^{\tau}(1 - \lambda_j^{\tau})$, $b_3 = (1 - \lambda_j^{\tau})(1 - \Theta_j^{\tau})$, and μ_t represents the disturbance term. The estimates of the b_1 and b_3 coefficients should therefore be positive, while b_2 should be negative. The b_0 coefficient is included here because we are not entirely sure a priori that the intercept should be zero.

Data

The time series used in this study are annual observations over the 1950–78 period. Many appear in publications of the U.S. Department of Agriculture (USDA); others are published by the U.S. Department of Commerce.

The annual levels of nominal gross investment in farm tractors published by the U.S. Department of Agriculture (USDA 1979b) were deflated to real terms by an unpublished fixed weight index of prices paid for farm tractors provided by the U.S. Department of Agriculture (I_t^{τ}).

The values for the h_{ji} weights for the engineering data (ED) capacity depreciation pattern are those reported by Penson, Hughes, and Nelson. Three frequently assumed capacity depreciation patterns are also examined in

this study. The values for the h_{ji} weights for the geometric decay (GD) pattern assumed by Heady and Tweeten are given by $\Phi(1 - \Phi)^{i-1}$, where $\Phi = 2/n$ and $n = 15$. The h_{ji} weights for the capacity depreciation pattern assumed by Cromarty are equal to 0 for $i = 1, \ldots, 14$, and 1 when $i = 15$. Likened to the wear-out of a light bulb earlier in this paper, this capacity depreciation pattern is referred to as the one-hoss shay (OHS) pattern by both Griliches and Coen because there is no deterioration in service until it is scrapped. Finally, the h_{ji} weights for the straight-line (SL) capacity depreciation pattern examined by Coen are equal to $1/n$, where $n = 15$.

The annual values for c_j^τ are found by using these h_{ji} weights in conjunction with equation (9) and then substituting the values of F_j into equation (8). We have followed Coen in assuming the real after-tax rate of return desired by farmers on their equity capital (ρ) is constant over the economic life of the investment (Coen, p. 63). The rate of interest on non-real estate loans at commercial banks was used to compute the real cost of debt capital (r). The time-series values for ψ were found by dividing the change in total farm debt by the level of gross investment in durable inputs reported by the USDA (1979a,b). The time series for α, the fraction of capital expenditures for durable inputs financed with internal equity capital, is equal to $1 - \psi$. Finally, the periodic loan payment (Z) was computed by dividing $q^\tau(1 - \alpha)$ by the equal-payment interest factor for r and n.

The quality of the time series for N_{jt}^τ and K_{jt}^τ depends upon how well the values of I_t^τ reflect quality changes in tractors over time. The deflated expenditure series should reflect changes in tractor horsepower over time since the USDA computes a fixed-weight prices-paid index based on information for five size and type categories of tractors. Using this index also guarantees that the deflated expenditure series also will reflect other technological improvements captured in the cost of the tractor. To the extent that some quality changes are not reflected in the cost of tractors, the coefficient estimates presented in the following section will reflect measurement er-

Choice of Estimator

The net investment model given by equation (20) can be viewed as a part of a simultaneous system of equations that includes other investment equations as well as supply equations for all inputs and the production function outlined in equation (4).[2] However, ordinary least squares (OLS) was used to estimate the b_i coefficients. The reasons for doing so were originally articulated by Griliches. Tractor purchases are "unlikely to influence agricultural product prices in the short run, both because the output effect of these purchases is likely to be small and because agricultural output is subject to relatively large random (weather) fluctuations" (Griliches, p. 188). And, the price paid for tractors, as a component of c_j^τ, is assumed to be predetermined since "tractors are produced and sold by a few major firms that announce their price early in the model year and rarely vary it within the season" (Griliches, p. 189). Thus, p, X, and c_j^τ are assumed to be predetermined.

To assess the effects of this assumption, a simultaneous equations estimator was used to estimate the coefficients in equation (20) for the ED pattern. Because there were more predetermined variables in this simultaneous system of equations than observations (n), the structurally oriented instrumental variable (SOIV) estimator, originally proposed by Fisher, was employed. SOIV is more efficient than some other "large model" estimators like two-stage principal components because it orders the predetermined variables in the model according to how closely associated they are with the explanation of p, X, and c_j^τ. The first $n - 1$ predetermined variables are then used to obtain first-stage estimates of these variables, which in turn are used in a second-stage OLS estimation of the coefficients in equation (20). For an indepth evaluation of this estimator, see Mitchell or Brundy and Jorgenson.

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[2] The input supply equations include not only the endogenously determined retail input price, but other variables like the capacity utilization index of the manufacturing sector and wholesale prices of raw materials. Stock demand equations for financial assets as well as real estate and non-real estate debt capital also can be

Empirical Results

The OLS and SOIV estimates of the b_i coefficients in equation (20) for the ED pattern are presented in table 1. Each coefficient has the expected sign and is significantly different from zero at the 10% level or less. The R^2 of .861 suggests that the variables in equation (20) do a good job of explaining annual real net investment in tractors. There is also no significant difference between the coefficient estimates given by the OLS and SOIV estimators since the R^2s in the first stage of the SOIV estimator were almost 1.0. This supports our use of OLS for the other capacity depreciation patterns. This conclusion is specific to this study and may not be general.

The OLS estimates of the b_i coefficients for the GD, OHS, and SL capacity-depreciation patterns reported in table 1 also had the expected signs. Note the coefficient associated with the lagged capital stock in the OHS equation was not significantly different from zero at the 10% level. Finally, we failed to reject the hypothesis of zero autocorrelation at the 5% level in all the equations in table 1 based upon an evaluation of the Durbin h-test statistic. Thus, no correction for autocorrelation was required.

A comparison of the R^2 values for the capacity depreciation patterns investigated in this study confirms both the results found by Coen and our hypothesis that the ED pattern most closely influences actual capital spending decisions. First, the R^2 associated with the SL pattern (.781) was higher than those for the OHS pattern (.774) and the GD pattern (.666). This is the same ordering Coen found for real net investment in equipment by manufacturing firms. However, the R^2 for the ED pattern (.861) was even higher. It appears, therefore, that both the SL and OHS patterns are better proxies for capital deterioration suggested by engineering considerations than the frequently used GD pattern.

We can compare these patterns further by examining the elasticities associated with the $(pX'c_j^T)$ variable, computed at the mean. The elasticity for the ED pattern was 2.64. This same elasticity for the OHS, SL, and GD patterns was 2.53, 4.33, and 6.59, respectively. Thus, the OHS and SL most closely approximate that of the ED pattern. The elasticity associated with the GD pattern substantially overestimates farmers' investment responses to changes in prices, interest rates, taxes, and other relevant variables.

We can also examine the assumption of Peterson and Hayami (constant service flow over a machine's life) by calculating the partial production elasticity for tractors, or β in equation (4), and comparing it to the β coefficient of the ED pattern. This elasticity for the jth capacity depreciation pattern is given by $-b_{1j}/b_{2j}$. The partial production elasticity for tractors with the ED pattern was .0303, while that for the OHS pattern was .0333. This result thus lends support to the Peterson-Hayami assumption of constant annual service flows. However, the coefficient on the lagged capital stock in the OHS equation was not significantly different from zero at the 10% level. Both of these elasticities were more than double that calculated for the GD pattern (.0123).

Table 1. SOIV and OLS Estimates of the Coefficients in the Real Net Investment Model Described in Equation (20)

Capacity Depreciation Pattern	b_0	b_1	b_2	b_3	R^2
Engineering data pattern (ED)					
SOIV estimator	−.063533	.001226	−.040470	.680080	.861
	(.267565)[a]	(.000279)	(.022219)	(.094767)	
OLS estimator	−.064095	.001277	−.040481	.679792	.861
	(.267625)	(.000280)	(.022223)	(.094810)	
Straight-line pattern (SL)					
OLS estimator	−.014116	.001486	−.066825	.532891	.781
	(.187595)	(.000334)	(.028846)	(.121163)	
One-hoss shay pattern (OHS)					
OLS estimator	−.083466	.001187	−.035510	.666579	.774
	(.381876)	(.000359)	(.028933)	(.118693)	
Geometric decay pattern (GD)					
OLS estimator	−.067464	.001094	−.088872	.339704	.666
	(.149014)	(.000250)	(.037363)	(.145518)	

[a] Figures in parentheses are the standard errors associated with the coefficients.

Considering the partial production elasticity for all machinery and equipment calculated by Shumway, Talpaz, and Beattie (.1335) during 1967–76, it appears the GD pattern substantially understates the role played by tractors in agricultural production. Finally, the partial production elasticity for tractors with the SL pattern (.0222) was considerably lower than the elasticity with the ED pattern.

In summary, the explanatory variables in equation (20) did a good job of explaining annual variations in real net investment in farm tractors over the 1950–78 period when the ED capacity depreciation pattern was used. While the GD pattern is easiest to implement because time-series data for R_j^τ and K_j^τ are readily available and the specification of c_j^τ is relatively simple, it represents the poorest proxy for the capacity depreciation pattern suggested by engineering considerations. If an estimate of the ED pattern is not available for a particular durable input, the results from this study and Coen's show that the OHS and SL patterns do a better job of approximating capital deterioration in aggregate investment analysis than the frequently used GD pattern.

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The Economic Feasibility of Crop Residues as Auxiliary Fuel in Coal-Fired Power Plants

Burton C. English, Cameron Short, and Earl O. Heady

Rising fossil fuel costs spark interest in crop residues as a renewable energy source. Residue costs for combustion in power plants are estimated in 1975 prices to evaluate their feasibility. Costs are estimated for farm production, transportation, and processing and handling at the energy recovery level. They are incorporated into an Iowa agricultural programming model which includes an electric utility sector. The model, including crop production, is solved for several scenarios—a base solution, energy price increases, and a sulfur constraint. Under these scenarios, crop residue replaces coal at 20%, 40%, and 60% of the 1975 Btu's consumed.

Key words: biomass, crop residue, Iowa Linear Programming Model.

Energy production from renewable resources is being discussed and examined. New technologies are being developed to use these renewable resources in fuel production. The United States is a nation rich in domestic energy resources, yet large quantities of energy are imported. Exxon Corporation examined the world's energy situation and concluded that a significant shift in the shares of energy supplied by various fuels could occur by 1990. In addition, they concurred with the Project Independence Task Force that synthetic fuel, solar, and other energy forms could be the basis for rapid expansion in future energy supplies. This paper examines a solar-based energy supply.

Crops capture solar energy, a flow resource, and combine it with other elements such as plant nutrients, water, and carbon dioxide to form grains, fruits, and fibers. A future purpose of U.S. agriculture also may be to provide energy. Significant amounts of energy in excess of food and fiber requirements may come from energy crops, agricultural by-products, crop residues, and animal wastes.

These products and by-products of the agricultural production process are forms of biomass. Biomass consists of carbon-to-carbon bonds. It is in these bonds that energy is stored and may be released to provide crucial fuels in the future.

The primary fuel stock considered here is crop residue, principally of the stalks and leaves of crops such as corn grown for grain. Now, some of these residues are removed or used in situs for livestock feed. For the most part, crop residues are incorporated into the soil. For every 16 kilocalories (kcal) produced through the capturing of energy by plants, 3.9 kcal are inherent in the residues left after harvesting (Nelson, Burrows, and Stickler). Some or all of the residues left in the field are useful for soil conservation, but also may have potential as a renewable energy source.

Objectives

This study examines the economic feasibility of using crop residues for direct combustion in Iowa's electrical generating power plants. A maximizing linear programming model representing Iowa's agricultural sector and electricity-producing complex is used to assess economic feasibility. The economic feasibility is evaluated with three different possible future scenarios: the Base, Increased Energy Prices, and Reduced Sulfur Emis-

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sions. Under each of these scenarios, crop residues are substituted for 0%, 20%, 40%, and 60% levels of coal consumed in 1975 by Iowa's power plants. The Base assumes 1975 costs, average 1970–75 yields and production prices, and 1975 sulfur emissions regulations. Both of the other scenarios assume a doubling of 1975 retail energy prices. Sulfur emissions are constrained in all solutions; current standards are used for sulfur for all scenarios except the Reduced Sulfur Emission where more restrictive standards are used along with doubled energy prices.

Study Area and Model

Iowa is selected as the study area because it has a high density of crop residues, and its electric utilities are dispersed. Iowa is divided into twelve agricultural producing regions consistent with Iowa's soil conservancy districts, and nineteen utility sectors (fig. 1). Small utilities (with an annual output of less than 5.0 megawatts) are not incorporated into the model as the fixed costs of processing residue for these power plants may be prohibitive. (Incorporation of small power plants would not affect overall results because of the small amount of residues that would be used.)

The linear programming model used in this study can be divided into two main components linked together by the production and use of crop residues. The model maximizes the net returns to crop production in Iowa and minimizes the costs of supplying coal and crop residues to Iowa power plants. A detailed description of the main components of the model is given in English et al., but the main structure of each component is described below.

The power plant component is similar to a feed mix model, where the "feeds" are a number of different coals and crop residues to be combined so that the fuel needs of the power plant are satisfied, the sulfur emission standards met, and costs minimized. The objective for the power plant sector is

$$(1)\quad \max = \sum_{n} \sum_{m} P_{nm}^{c}\, Q_{nm}^{c} - \sum_{m} P_{n}^{r} R_{m}^{r},$$

and is subject to m fuel constraints:

$$(2)\qquad B_{n}^{c} Q_{nm}^{c} + B_{n}^{r} R_{m}^{r} \geq BTU_{m}.$$

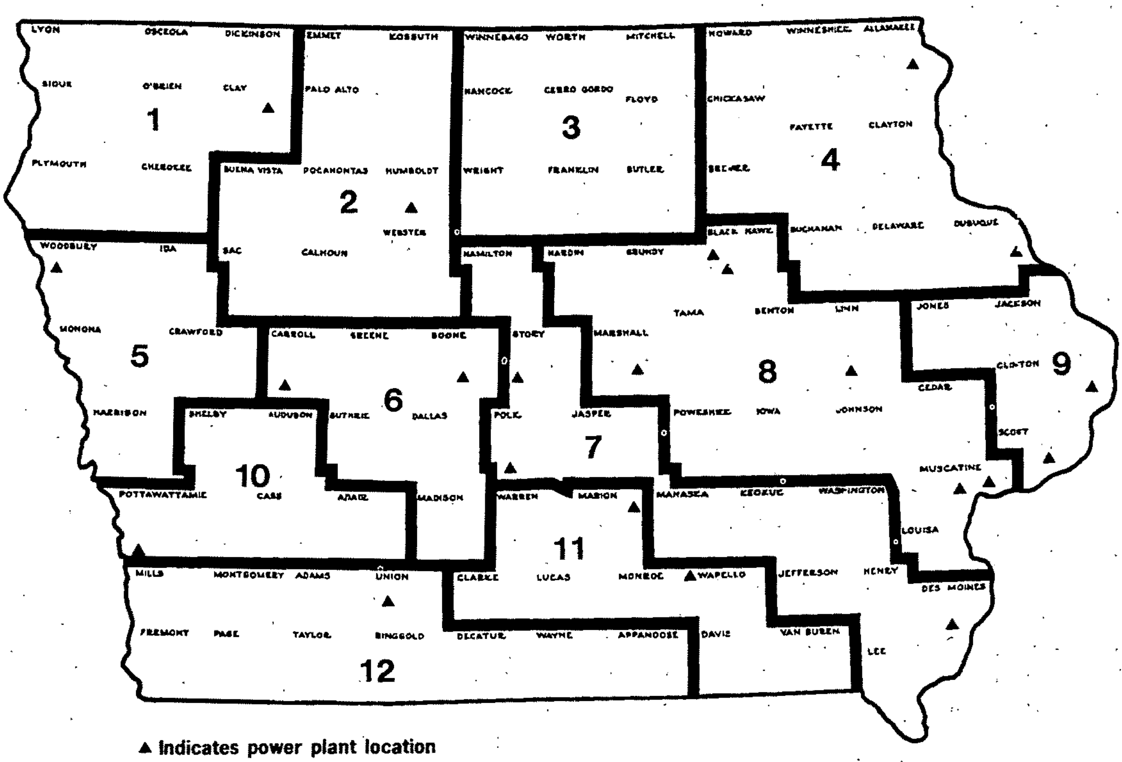

Figure 1. Twelve agricultural regions and power plant location

m emission constraints;

$$(3) \qquad S_n{}^c Q_{nm}{}^c + S_n{}^r R_m{}^r \leq SO2_m,$$

and m crop residue constraints;

$$(4) \qquad B^r R_m{}^r \geq (PROP)\ BTU_m,$$

where n = 1 to 9 for 9 coal types and m = 1 to 18 for 18 power plant locations; $P_{nm}{}^c\ Q_{nm}{}^c$ is the cost of coal n to power plant m; $P_m{}^r R_m{}^r$ is the cost of crop residues to power plant m; $B_n{}^c\ Q_{nm}{}^c$ is the heating value of coal n to power plant m; $B_m{}^r R_m{}^r$ is the heating value of crop residue to power plant m; $S_n{}^c\ Q_{nm}{}^c$ is the sulfur emissions generated from coal n at power plant m; $S_n{}^r\ R_m{}^r$ is the sulfur emissions generated from crop residue at power plant m; BTU_m is the quantity of fuel required by power plant m; $SO2_m$ is the maximum sulfur emissions allowed at power plant m for the fuel quantity BTU_m; and $PROP$ is the proportion of fuel supplied by crop residues.

The value for the proportion of energy supplied by crop residues is parametized over the values 0.0, 0.2, 0.4, and 0.6, with changes in the objective function coefficients made to reflect size economies in crop residues. The coal types include both washed and unwashed coal from Iowa and other midwestern states and low sulfur western coal from Wyoming.

For several reasons, 60% was selected as the upper limit on the amount of coal to be replaced with crop residues. Green estimates that up to 60% of the coal could be replaced before particular emission standards would be exceeded without additional particulate collectors. Crop residues also have lower density than most coals, so a reduction of boiler capacity is likely where power plant boilers are designed to close specifications for a low ash-high BTU coal. For older traveling grate furnaces in Iowa, the 60% limit is a reasonable approximation of the amount of coal that can be replaced.[1] However, early attempts at burning MSW in suspension boilers were successful only in very large units but the installation of a dump grate in the bottom of two Ames suspension boilers allowed 20%–25% of the coal to be replaced and further modifications are expected to raise this limit to 30%. Thus, the upper limit of 60% coal replacement with crop residues for retrofitting boilers in Iowa is a maximum with likely technology in the near future and may not be feasible without derating some of the boilers. Only costs of boiler modification similar to those incurred in Ames are included in the objective function.

The crop production component maximizes returns to crop production defined as returns to land and management:

$$\max = \sum_i \sum_j P_{ij}{}^a Q_{ij}{}^a - \sum_h \sum_j \sum_k \sum_l (T_{hjkl}{}^a L_{hjkl}{}^a T_{hjkl}{}^r L_{hjkl}{}^r),$$

subject to 2 jl land constraints;

$$\sum_h \sum_k (L_{hjkl}{}^a + L_{hjkl}{}^r) \leq L_{jl}, \text{ and}$$

$$\sum_h \sum_k L_{hjkl}{}^r \leq L_{jl}{}^r,$$

ij production constraints;

$$Q_{ij}{}^l + Q_{ij}{}^a \leq \sum_h \sum_k \sum_l (Y_{hjkl}{}^l L_{hjkl}{}^a + Y_{hjkl}{}^a\ L_{hjkl}{}^r),$$

2 j crop residue constraints;

$$R_j{}^l \leq \sum_h \sum_l \sum_k Y_{hjkl}{}^r\ L_{hjkl}{}^a,$$

$$\sum_m R_{mj}{}^r \leq \sum_h \sum_l \sum_k Y_{hjkl}{}^r\ L_{hjkl}{}^r,$$

and soil loss is estimated by

$$S = \sum_h \sum_j \sum_k \sum_l (S_{hjkl}{}^a\ L_{hjkl}{}^a + S_{hjkl}{}^r\ L_{hjkl}{}^r),$$

where i = 1 to 8 for crops produced, j = 1 to 12 for 12 producing areas, h = 1 to 40 for crop rotations, k = 1 to 12 for 12 conservation and tillage practices, l = 1 to 5 for 5 land classes, and m = 1 to 18 for the power plants; $P_{ij}Q_{ij}$ is the value of crop i produced in producing area j; $T_{hjkl}{}^a L_{hjkl}{}^a$ is the cost of production for rotation h in region j with conservation/tillage practice k on land class l with crop residues removed for combustion in power plants; $L_{hjkl}{}^a$, $L_{hjkl}{}^r$ are the amounts of land used for rotation h in region j with conservation/tillage practice k on land class l without and with the removal of crop residues for combustion, respectively; L_{jl} is the total amount of land available in region j, land class l; $L_{jl}{}^r$ is the total amount of land available in the power plant collection areas; $Y_{hjkl}{}^i$ is the yield per rotation acre of crop i in rotation h, region j, with conservation/tillage practice k on land

[1] As stated by Merlin Hove, City of Ames, Iowa, the traveling grate furnaces in Ames have successfully operated with up to 60% of the coal replaced with municipal solid waste.

class l; $Q_{ij}{}^l$ is the amount of crop i required for livestock feed in region j; $Q_{ij}{}^a$ is the amount of crop i sold in region j; $Y_{hjkl}{}^r$ is the harvested residue yield per rotation acre for rotation h in region j, with conservation/tillage practice k on land class l; $R_j{}^l$ is the amount of residues required as livestock roughage in region j;[2] $R_{mj}{}^r$ is the amount of residues required by power plant location m in region j; $S_{hjkl}{}^a$, $S_{hjkl}{}^r$ are the soil losses generated by rotation k in region j, with conservation/tillage practice k on land class l for rotations in which residues are removed and without residues removed, respectively; and S is the total amount of soil loss.

Net agricultural returns can be derived by subtracting the objective function for the power plant component from the overall objective function. The costs of producing agricultural commodities included in the objective function coefficients consist of labor, machinery, pesticides, energy, and fertilizers. Returns to land and management are determined endogenously by the model. The agricultural sector uses energy in the production and harvesting of crops: direct energy requirements for machine operation and crop drying are computed and indirect requirements of energy for agricultural chemicals are included. The use of coal and crop residues requires energy; and finally, the power plant component uses energy for transportation and processing. The amount of energy by fuel type is quantified as an important result and is needed to change objective function values for the scenario displaying increased energy prices.

Crop Residue Costs

The costs of crop residues are estimated for three stages of crop residue production and energy conversion—farm level, transportation, and processing and handling at the power plant. Costs included in the farm level stage are harvesting and agronomic costs with initial storage of the residues assumed to occur on the farm. Transportation costs are estimated as a function of unit transportation costs and the size and shape of the collection area, the latter depending on the location and size of the plant. Processing and handling costs at the power plant include capital investment in buildings and equipment, wages, and operation and maintenance costs. The processing and handling system requires both the reduction of residues to a homogenous size and short-term residue storage. Processing and handling costs are subject to considerable economies of size, which also depend on the power plant.

Farm Level Costs

The removal of crop residue has possible adverse agronomic effects from reduced organic matter and moisture retention capacity, increased susceptibility to erosion, and the lost fertilizer value of the plant material. While organic matter generally is recognized as a valuable soil amendment, there is not a clear relationship between crop residue removal and yields. Adams, Morris, and Dawson found that stalk removal had no effect on yields for continuous corn with and without a cover crop or for corn grown in rotation. Triplett and Mannering conclude that nonlegume crop residues seem to have little value except in erosion control. Bauer actually found that adding residues had either no effect or a slightly depressing impact on yields. Thus, it is assumed that no yield penalty or other cost is incurred as residue is removed. Substantial costs are incurred because of the loss of the fertilizer value of the residues removed. Additional amounts of the major plant nutrients—nitrogen, phosphorus, and potassium—have to be applied to maintain yields. When residues are incorporated into the soil, not all of the nutrients become available to next year's crop. Residues decay over long periods of time, releasing only a fraction of the nutrients in any year. To estimate the value of these residues, a decay schedule is used to estimate the discounted present value of the flow of nutrients. Broadbent, in a literature review on the mineralization of organic nitrogen, found a range of decay rates from less than 1.0% to 10%. It is assumed that the decay rate for nitrogen and phosphorus is 5%. Potassium is not discounted because it is readily washed out of crop residues and becomes readily available to the succeeding crop.[3] The net dis-

[2] This constraint insures that aftermath demands assumed in the exogenous livestock rations will be met. This was done to develop a model reflecting current uses. It is true that once crop residues have a market demand, then this quantity would vary. No attempt is made here to estimate this.

[3] Personal communication with W. D. Shrader, Department of Agronomy, Iowa State University, August 1977.

counted fertilizer value, or the opportunity cost of fertilizer, is shown in table 1.

Many studies have been made of the costs of harvesting plant materials using a variety of harvesting systems. Five basic packaging systems are examined: (*a*) small rectangular bales, (*b*) cubing, (*c*) large rectangular bales, (*d*) large round bales, and (*e*) stacks. The first two systems are not economically viable. While costs of large round and rectangular bales are competitive, difficulties are foreseen in handling and storing these residues. Large stacks have several advantages over other systems in residue harvesting. The stack can be placed at the roadside without protection since stack deterioration is less than would occur with other harvesting systems. Truck mounted stack-movers have been developed to facilitate transfer. Finally, assuming windrowing would not be necessary and that 1,000 tons are harvested per year per stack harvester, they are the least costly. This finding concurs with those of Abdullah and Hitzhusen.

Transportation Costs

Transportation costs are a small but an important portion of total costs. They are an increasing function of transportation distance, so a series of costs is estimated for a range of average round-trip distances.[4] The average round-trip distance depends on the size and shape of the collection area which, in turn, depends on the total quantity of crop residues demanded, the density of crop residue within the area, the demand for residues by competing uses, and the proportion of farmers harvesting residues. The collection areas for crop residues reflect an assumed 25% participation rate, as recommended by Shrader. Although this increases transportation costs, we think this assumption is necessary to make the model realistic.

In most of the Midwest, the road system is an east-west, north-south grid. The loci of points equidistant from each power plant form a diamond shaped area. A marginal transportation distance is selected so that the amount of available residues is equal to that required by the power plant. Assuming that crop residues on a given section of land are harvested once every four years and livestock residue feed demands are met, the average transportation distance is two-thirds the marginal or perimeter distance.[5] Per ton transportation costs, including loading and unloading costs, are \$0.76, \$0.95, \$1.05, \$1.20, \$1.50, and \$2.00 for round trip distances at 4, 10, 15, 20, 30, and 50 miles, respectively (English et al.).

Processing Costs

Costs of processing crop residues are estimated from hypothetical processing plants. Facilities do not now exist that are designed and built to prepare crop residue for energy conversion. Like a solid waste treatment plant, the flow line of the hypothetical processing plant has four main elements.[6] Modifications for introducing crop residues into the boilers are included in these costs. Estimates of processing and handling costs show considerable economies of size (table 2).

Capital costs, in 1978 dollars, are annualized using a capital recovery factor with a 10% discount rate and a square type depreciation schedule (Smith).[7] The processing equipment is assumed to have a useful life of twenty years, while a six-year life span is assumed for the pneumatic system. Salvage values are assumed equal to dismantling costs. The costs of

Table 1. Discounted Present Value of Nutrients per Ton of Crop Residue Removed by Crop

	Fertilizer value[a] of			
Crop	Nitrogen	Phosphorous	Potassium	Total Value
	(\$/ton)			
Corn	1.39	0.32	2.67	4.38
Oats	0.75	0.31	3.32	4.38
Sorghum	1.35	0.24	2.63	4.22
Soybeans	2.88	0.38	2.08	5.34
Wheat	0.76	0.10	1.93	2.79

[a] Present value calculated in 1975 dollars using a 10% discount rate and prices of 18¢, 26¢, and 10¢ per pound for nitrogens, phosphorus, and potassium, respectively.

[4] Using expected round trip distances has implications for the institutional arrangements by which crop residues are collected. If each farmer were to deliver his own residue and the power plants are not discriminating monopolists, then the marginal distance should be used.

[5] The expected distance is determined from $\int_0^r \int_0^{r-x} (x + y)\,(2/r^2)\,dydx = 2/3r$, where a coordinate system in x and y is used. $x + y$ is the transportation distance, r is the perimeter distance, and $2/r^2 = f_{x,y}(x,y)$ is the probability density function for a random selection from anywhere within the perimeter.

[6] The four main elements include the tipping floor where residues are received, the size reduction equipment (assumed to be a hog, as used in the forest industry) which reduces residues to a homogenous size, storage facilities, and, finally, boiler modifications to permit residue burning. Conveyors are needed between the main elements.

[7] These costs were developed with the help of Harvey Funk and Dan Morriouri of Henningson, Durham, and Richardson, Omaha, Nebraska.

Table 2. Capital Costs for Crop Residue Processing and Handling Plants

Item	Processing Plant Capacity in Tons per Day				
	100	300	600	900	1200
	($ thou.)				
Sitework	112.4	135.6	145.7	153.7	160.1
Buildings	168.6	368.7	673.2	1,016.0	1,377.9
Equipment	666.4	951.7	1,150.8	1,390.7	1,532.3
Rolling stock	38.1	51.4	95.8	95.8	95.8
Engineering & contingency	249.1	330.6	450.2	586.9	689.8
Pneumatic system	154.3	154.3	154.3	154.3	154.3
Total	1,388.9	1,992.3	2,670.0	3,397.4	4,010.2

the pneumatic system and for the modification of existing boilers were those incurred at Ames, Iowa, in adapting to municipal solid wastes (Kosolchareon). While individual capital cost components may differ, the total capital costs are similar to Abdullah and Hitzhusen. For a 100-ton-per-day crop residue-processing facility, the capital costs assumed here are $1.39 million compared to Abdullah and Hitzhusen's estimate of $1.43 million. The economies of size in processing and handling crop residues outweigh diseconomies of size in transportation. This indicates that the lowest total costs for crop residues will be incurred by the larger power plants (table 3).

Results

Crop residue use affects crop production, energy consumed, nitrogen demanded, agricultural production cost, and net income. The impacts of utilizing crop residues on Iowa's agricultural sector are first examined, then the economic viability of using crop residues are determined by examining the costs and benefits of residue use compared to coal use.

Table 3. Total Costs of Crop Residues to the Power Plant

Cost Stage	Processing Plant Capacity in Tons per Year				
	24,800	74,400	148,800	223,200	297,600
	($/ton)				
Farm level	11.68	11.68	11.68	11.68	11.68
Transportation	.79	.91	.99	1.05	1.11
Processing and handling[a]	12.66	6.11	4.28	3.63	3.22
Total	25.13	18.70	16.95	16.36	16.01

[a] Includes capital costs, operating and maintenance costs, and labor costs.

As energy prices increase, total changes in energy use, measured in Btu's, do not vary significantly from one scenario to another. However, energy use by the agricultural sector increases with removal of crop residues. Energy use from conventional fuel sources (other than coal) increases with the substitution of crop residues. This increase is far less than the coal energy replaced by residues (table 4). Thus, the use of crop residues results in a large reduction in total energy from coal and a small increase in the use of diesel, natural gas, electricity, and liquid petroleum gas.

Impacts on Iowa's Agricultural Sector

The total value of endogenous crops exceeds $3 billion in all scenarios examined. The ag-

Table 4. Total Energy Use by Source of Energy

Scenario	Source					
	Coal	Diesel	Natural Gas	Electricity	LPG[a]	Total
	(trillion Btu's)					
Base						
0	118	41.3	35.0	1.3	13.3	208.9
20	94	42.2	36.0	1.5	13.4	187.1
40	71	43.7	37.0	1.7	13.6	167.0
60	47	46.0	37.9	1.8	13.7	146.4
Increased energy prices and reduced sulfur emissions						
0	118	40.8	31.9	1.2	12.2	204.3
20	94	41.6	32.9	1.4	12.4	182.3
40	71	43.3	34.0	1.6	12.6	162.5
60	47	45.5	34.9	1.7	12.7	141.8

[a] Liquid petroleum gas.

ricultural sector is affected by increased energy prices and by the amount of residues harvested for the power plants but is, of course, unaffected by reduced sulfur emissions; the gross value of crops produced is identical for both the Increased Energy Prices and Reduced Sulfur Emissions scenarios. The gross value of crops produced is 1.78% lower in these scenarios than the base scenario with no coal replacement (table 5). As the percentage of coal replaced with crop residues rises to 60%, the gross value of crops produced decreases to 0.54% of the value produced in the Base Scenario. This shift is for the most part caused by a shift from soybean to corn production, a higher residue-yielding crop.

Nitrogen use decreases between 8.5% to 9% at all levels of crop residues as energy prices increase. The harvesting of crop residues results in additional nitrogen requirements of 10, 20, and 30 thousand tons to replace the nitrogen used in crop production as cropping patterns change. More nitrogen-intensive rotations are required as residue demand increases.

Several components must be examined before net income is derived. As previously mentioned, the objective function includes not only the costs and returns attributed to agricultural production, but also the minehead costs, transportation and handling costs of coal used by Iowa's power plants, and the transportation and processing costs of crop residues. When these components are added to the objective function, net income to the crop and crop residue-producing portion of the agriculture sector is derived. Net income then is the monetary return to Iowa farmers, but does not reflect any cost for land, management, or the risk aspects of agriculture (table 6). As 20%, 40%, and 60% levels of crop residue use are assumed, a respective decrease in net income of 1.36%, 2.81%, and 4.17% occurs in the Base scenario. Thus, the farmers must receive at least this amount as a return on labor and capital used before residues will be provided to the power plants.

Table 5. Gross Value of Crops Marketed and Percentage Changes between and within the Scenarios

Percentage of Coal Replaced	Value of Crops for: Base Scenario	Increased Energy Prices	Reduced Sulfur Emission
	($ mill.)		
0	3,461.5	3,399.9	3,399.9
20	3,467.4	3,404.6	3,404.6
40	3,475.1	3,383.7	3,383.7
60	3,483.3	3,381.6	3,381.6

As energy prices increase and sulfur levels are further restricted, the net income decrease is much less. This loss in net income is due primarily to the agronomic and harvestings costs borne by the farmer. An additional cost is incurred because of shifting crop patterns.

Economic Feasibility of Crop Residues

The costs of crop residues include both direct and indirect costs (table 6). The direct costs are those attributed to harvesting, transporting, and processing the residues plus the agronomic costs of nutrient replacement. The indirect costs include those due to cropping pattern shifts caused when residues are supplied by farmers. Other costs of crop residues, such as organic matter maintenance and decreased productivity over the long run, and benefits, such as reduced pesticide use and reduced fall plowing, are not incorporated within the scope of the study. These components would affect the indirect costs of crop residue.

On a Btu basis alone, the use of crop residues becomes economically feasible only when coal and other energy prices double from approximately 1977 levels (table 7). Even at this point, the feasibility of residues is marginal. If the benefit of the sulfur contribution is credited, however, the doubled coal and energy price scenario indicates crop residues are indeed feasible with a net benefit of $0.25 and $0.43 per million Btus (MMBtu) for the 20% and 60% levels, respectively. If sulfur emissions are further constrained, this added benefit increases to $0.36 and $0.49 per MMBtu. This last scenario is perhaps most relevant because power plants usually meet legal constraints by a wide margin.[8]

The costs incurred by farmers and the power plant operators are shown in figure 2. These results are consistent over all the scenarios, though the percentages differ slightly because of increased energy costs. The figure shows that the farmer's share of the

[8] From information provided to the public at the Iowa Department of Environmental Quality public information meeting, 14 July 1977.

Table 6. Values for the Objective Function, Coal Cost, Transporting and Processing of Crop Residues, and Net Income, by Scenario

Scenario	Objective Function	Coal Cost	Transporting and Processing of Residues	Net Income
	($ mill.)			
Base				
0	1,215.1	99.7	0	1,314.8
20	1,208.3	79.0	9.5	1,296.9
40	1,202.7	58.5	16.6	1,277.8
60	1,202.0	38.1	19.9	1,260.0
Percentage change from base for	(%)			
Increased energy prices				
0	−19.8	157.3	0	−14.0
20	−19.5	+157.8	121.8	−14.5
40	−19.3	+158.5	137.9	−15.0
60	−19.0	+160.9	156.8	−15.3
Reduced sulfur emissions				
0	−23.4	+201.3	0	−13.9
20	−22.2	+199.0	121.8	−14.5
40	−21.3	+200.8	137.9	−15.0
60	−20.1	+191.0	156.8	−15.5

costs increases as the percentage of residue used increases. This increase is primarily due to the fixed costs inherent in the power plant's processing facility, a large capital investment.

This analysis does not include any costs associated with risk. In addition, the hypothetical processing plant may not be optimum in the real world. Additional benefits received by farmers for their residue harvesting efforts, including reduced fall plowing and reduced need for pesticides and herbicides, are not incorporated into the analysis. These benefits could allow the power plant to pay less to

Table 7. Economic Feasibility of Crop Residues When Evaluated on a Btu Basis Alone

Type of Fuel by Scenario	Percentage BTU Replacement of Residue for Coal at 20	40	60
	($/MMBtu)		
Base			
Coal	0.84	0.83	0.81
Crop residue	1.14	1.12	0.90
Difference[a]	−0.30	−0.29	−0.09
Double energy prices			
Coal	1.30	1.30	1.28
Crop residue	1.40	1.40	1.15
Difference[a]	−0.10	−0.10	+0.13
Double coal and energy prices			
Coal	1.65	1.65	1.58
Crop residue	1.40	1.40	1.15
Difference[a]	+0.25	+0.25	+0.43
Reduced sulfur emissions			
Coal	1.76	1.71	1.63
Crop residue	1.40	1.40	1.15
Difference[a]	+0.36	+0.31	+0.48

[a] Negative quantities indicate lower costs for coal, while positive figures show lower costs for residues.

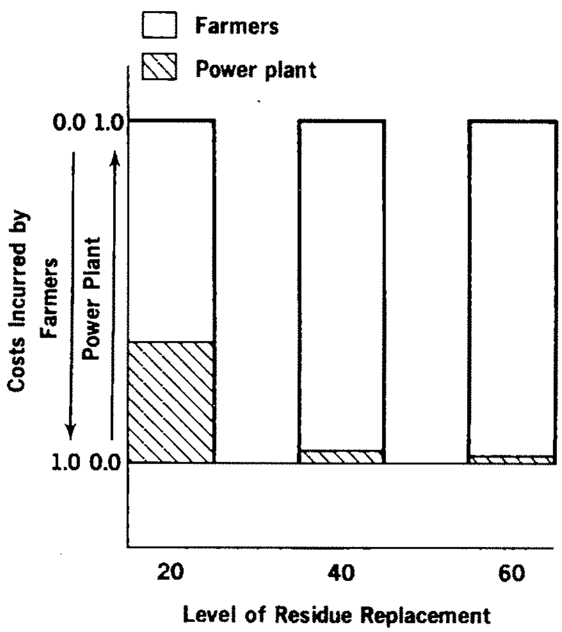

Figure 2. Proportion of costs incurred by the farmers and power plant operators

farmers than otherwise. Recall that the 60% replacement level is not currently feasible for all power plants. The economics for a particular power plant must be examined on an individual basis, as was done for two power plants by Abdullah and Hitzhusen.

The results of this study suggest that under the rapid upward trend in energy prices, the use of crop residues may indeed be feasible. This development could permit a large reduction in low-sulfur coal use for a small increase in other conventional energy sources.

While this study indicates that residues are a feasible feed stock for electrical generation, several parameters should be examined in a more detailed manner. These parameters include the farmers' willingness to harvest residues, the farmers' opportunity cost, and estimates of actual plant capacity for stover combustion. Each of these variables is local in nature as they will change from one power plant to another. Before recommending that power plants incorporate residue as a feed stock, a study of area farmer attitudes toward residue harvesting and storing should be conducted.

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Agricultural Export Dumping: The Case of Mexican Winter Vegetables in the U.S. Market

Andrew Schmitz, Robert S. Firch, and Jimmye S. Hillman

This paper examines the 1978 agricultural dumping charge brought by Florida winter vegetable producers against Mexican growers. It discusses "fair value" in the context of three antidumping criteria: prices at home and abroad, selling below cost of production, and third-market test. The U.S. Department of Commerce found in favor of the Mexican producers by using the third-market test—a test which leads to ambiguous results. It is the authors' contention that the law should be changed so that future cases can be decided on a "normal business practice" concept, accounting for production and costing decisions unique to highly perishable products.

Key words: agricultural dumping, fair value, normal business practice.

Among international trade economists, the term "dumping" usually refers to cases where the good is either exported abroad at a price below that set in the home market or it is sold to importers at a price below production costs. Most of the theory and legal cases have involved manufactured goods. The antidumping case examined in this paper deals with highly perishable agricultural products. The case is the October 1978 dumping charge brought by Florida winter vegetable producers against Mexican growers. Because of climatic conditions, Florida is the only major geographic area in the United States that can produce substantial volumes of fresh vegetables during the winter months. These vegetables are marketed in the United States and Canada. Competing for these markets with Florida producers are Mexican growers situated in the state of Sinaloa. Slightly more than half of the tomatoes, cucumbers, peppers, eggplants, and squash sold in the United States and Canada in the winter months come from Mexico.[1] Of the five major items considered (tomatoes, cucumbers, peppers, eggplants, and squash), Mexico's market share increased through much of the early part of the period considered, at the expense of Florida's share, even though Florida's absolute production level increased.

In contrast to manufactured goods, dumping investigations for perishable agricultural commodities have been rare. During 1976, twelve antidumping investigations were concluded, but no agricultural products were involved. However, there were some agricultural antidumping cases in other years, for example, Concord grapes from Canada (1969) and chicken eggs from Mexico (1971) and from Canada (1975). However, the U.S. Treasury Department, in investigating the complaint by the Florida vegetable industry against Mexican producers, did not use the approaches established in these cases; apparently they provided little or no precedent for appropriate methods to be used.

The antidumping investigation was initiated by the U.S. Treasury Department under the provisions of the Antidumping Act of 1921, as amended. The Act requires a Tentative De-

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[1] Excellent data from which to make comparisons between the Florida and Mexican vegetable industries are contained in McCalla and King; Simmons, Pearson, and Smith; and Zepp and Simmons (1979, 1980). In addition to general production and marketing trends unfavorable to Florida growers, short-term phenomena have permitted increases in Mexican vegetable exports. These include the Florida winter freeze in the 1976–77 crop year and the devaluation of the Mexican peso in 1976.

termination to be announced after a specified period of time. However, Florida interests withdrew their petition on 25 July 1979. Several agencies of the U.S. government had requested the withdrawal of the petition in the hope that a resolution could be negotiated and Mexican interests would agree to restrict their shipments to the U.S. market under special circumstances. Such a solution would have precluded further action under the Antidumping Act. Efforts to negotiate a settlement failed, and on 19 October 1979 the petition was refiled. The Tentative Determination (5 November 1979) found that certain fresh winter vegetables from Mexico were not being sold at less than fair value within the meaning of the Act.

On 1 January 1980, the antidumping provisions of the Trade Agreements Act of 1979, which amended the Tariff Act of 1930, became effective. The Antidumping Act of 1921 was repealed, and the responsibility for dumping determinations was transferred to the U.S. Department of Commerce. The transition rules in the 1979 act were sufficiently vague so that the Department of Commerce first ruled that the antidumping investigation of Mexican vegetables had been automatically terminated at the transition date. Later it ruled that continuation of the investigation was consistent with the intent of Congress. The Final Determination became effective on 28 March 1980. The summary statement of findings, "that certain fresh winter vegetables from Mexico are not being sold at less than fair value within the meaning of Section 735 of the Tariff Act of 1930, as amended" (U.S. Department of Commerce, p. 1), was virtually identical with that of the Tentative Determination.

In this paper, we discuss three dumping criteria which have been used to determine "fair value": (*a*) comparing prices at home and abroad, (*b*) selling below cost of production, and (*c*) comparing prices in two or more import markets (the third-country test). We show the inconsistencies which can arise among these various tests and how the concept of fair value permits a wide scope for analytical techniques and judgment in case analysis. The outcome of the Mexican-Florida lawsuit is then discussed in the context of both law and economics. We argue that the law should be changed so that economic analysis can play a more effective role in determining fair value in dumping cases. Specifically, we contend that the final decision by the U.S. Department of Commerce should have been based, at least in part, on a cost-of-production criterion to reflect both the nature of agricultural production and normal business practices. Instead, the Department used the third-market test (i.e., comparing U.S. and Canadian prices for vegetables from Mexico). This is because a cost-of-production test, as it is now written into the law, cannot be applied to most agricultural goods.

This case is important for several reasons. First, the outcome was unpredictable because of the relatively unconstrained method of investigation. Most substantive dumping cases have been in manufactured goods. In these cases, either or both of the following criteria have been used: (*a*) selling abroad at a price below that charged at home and (*b*) selling abroad at a price below the cost of production. The agricultural dumping case discussed in this paper is somewhat unique because (*a*) an agricultural good is considered for which there is little legal precedent; (*b*) the cost of production has a different meaning for agricultural than manufactured goods because of the importance of weather, storage problems, and implicit pricing of land and family labor; and (*c*) in this case, there is no home (Mexican) market. Second, the methods used to investigate the dumping of Mexican vegetables may establish important precedents for future dumping investigations of other perishable commodities. Third, the finding of no dumping in this case may discourage other U.S. producers of perishables from pursuing dumping investigations of foreign competitors.

The Theory of Dumping and Tests Used in Antidumping Investigations

Generally, dumping is understood to mean that a product is exported at a price lower than that at which the identical or similar product is sold by the same producers in the exporting country's domestic market (Corden). This subject has received much attention in the commercial policies and tariff legislation of most countries. Also, there is a General Agreement on Tariffs and Trade (GATT) Antidumping Code which, in certain cases, legitimizes antidumping tariffs.

An extreme case of dumping is shown in figure 1. Suppose the supply schedule for export producers is S and marketing is carried out by an exporter-grower association which has monopoly power. The demand in the ex-

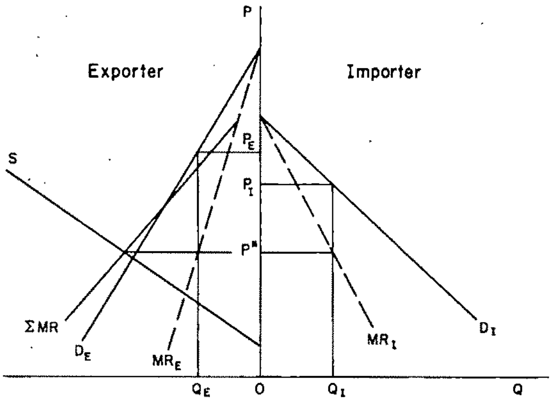

Figure 1. Export dumping: importer price below home market price

porting country (domestic market) is D_E, while D_I is the demand in the foreign market. Under an optimal price strategy, the exporter will charge price P_E in the domestic market and P_I in the foreign market, which is below the domestic price. (This solution is determined by equating S with the sum of the marginal revenue schedules, MR_I and MR_E.) Pricing in this way is dumping. However, to price in this manner, the exporter has to be a monopolist.

The case examined here is more interesting than many antidumping investigations in manufactured goods because the important criterion used in antidumping cases—selling abroad at a price below that in the home market—could not be used. Fresh winter vegetables produced in Sinaloa, Mexico, are produced with the sole intent of sale for export. Except for an insignificant amount, exporters sell into the Mexican market only those vegetables that fail to meet the high-quality standards for export to the United States and Canada. Geography and transportation costs exclude Sinaloa from profitable sales in the population centers of Mexico. In effect, similar merchandise is not sold in the home market.

Sometimes dumping is described as exporting below the costs of production. In figure 1, if this criterion had been used instead of the relative prices among markets, no dumping would have occurred. The cost of producing Q_E + Q_I is only P^*, clearly below both the domestic and export prices. As a result, the conclusion whether or not dumping has occurred is dependent on the criterion used. As figure 1 shows, if an industry behaves as a monopolist, dumping does not occur if the selling below-cost criterion is used. But it does occur if the criterion of selling abroad cheaper than at home is employed.

With perishable agricultural products, the criterion of selling below cost of production reflects a different meaning than for manufactured goods. Unfortunately, as the law now stands, no distinction is made between the two. On economic grounds, this makes little sense. Weather plays a major role in the production of farm products; hence, outcomes are not known at the time the crops are planted. At harvesttime, a grower may not be able to sell his product at a price high enough to cover both fixed and variable costs; yet, he may decide to harvest and sell the crop if the price will cover harvesting costs.

Later it will become clear why, if the Department of Commerce wanted to rule in Mexico's favor, it did not use the cost-of-production test. Instead, the Treasury Department argued that, since the first criterion could not be used, a price comparison should be made between Canada and the United States and, if the prices were similar, the antidumping case could not be supported. This criterion is illustrated in figure 2. The export supply is S, but the domestic demand is absent. There are two importers represented by demand D and the total demand schedule, TD. Under purely competitive conditions, the exporter would receive P^* in both markets. Because domestic demand is absent, the most widely used criterion of comparing prices at home and abroad is inappropriate for determining if dumping is occurring. Clearly, dumping is not taking place if the price charged in both markets is P^*. However, does this test lead to results consistent with the other widely used criteria? Also, does it show that dumping is not, in fact, occurring? One problem

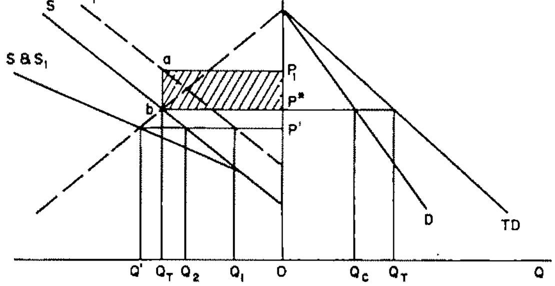

Figure 2. Export dumping: the use of the third market test

with the third-country test is that it can lead to results inconsistent with the costs-of-production criterion. Suppose that the true supply curve is S_1 instead of S in figure 2. In this case, the price needed to cover the cost of producing Q_T is P_1. If sales are made at P^*, area P_1abP^* must be made up from past profits, government subsidies, or a depletion of fixed capital. Here the exporter charges the same price, P^*, to the two importers. This is not dumping under the third-market criterion, but it is under the criterion of selling below cost. As a result, it does not necessarily follow that the third-country criterion leads to results consistent with the more commonly used criterion—selling below the costs of production. Even if the third-market test were met (i.e., P^* was charged in both markets ignoring transportation costs) virtually no conclusions can be drawn about dumping. If S_1 is the supply curve and price P^* is charged, then dumping exists. If, on the other hand, S is the supply curve, dumping does not occur. If the third-market test is met, one can say that either dumping has occurred in both markets or it has occurred in neither. That is all.

The third-market test to determine fair value seems to have as its basis the model in figure 1, where D_E and D_I are now demand curves for importers (the home market demand is absent) and S is the exporter supply curve. In the Florida-Mexican case, if D_I were the demand in the United States and D_E the demand in Canada, dumping would have occurred in the U.S. market at price P_I. In the absence of subsidies in the export countries, dumping is occurring even when the exporter is making excess profits in both markets through price discrimination. These results are modified only slightly when a supply curve is introduced in the import market.

Dumping should not be confused with phenomena caused by differences in production costs. If producers in an importing country continue to lose their market share through time even when competing imports are not subsidized, dumping is probably not occurring since export producers cannot sell below production costs forever. Consider figure 2, where TD is the demand by the United States and Canada for fresh vegetables. Assume that S is the supply in Mexico and S_I is the supply of fresh vegetables in the United States. The difference in these supply curves could be due, for example, to labor costs differences. The free market price is P'; OQ^2 of the market is supplied by Mexico and only OQ_1 by the United States. If the difference between S and S_1 widens and is not offset by tariffs, then the U.S. market share will continue to decline. This is not because of dumping—it is caused by factors which make vegetable production cheaper in Mexico than in the United States. On the other hand, if the distance between the two supply curves narrows through time, it is again difficult to argue that dumping is occurring. How does one dump effectively and still lose market share through time?

The Interplay of Law and Economics

For antidumping investigations, the law establishes this basic premise: Generally, sales at less than fair value occur when merchandise exported to the United States is sold in the United States at a price which is less than (*a*) the price of such or similar merchandise sold in the home market; (*b*) in the absence of a viable home market, the price at which it is sold in the third country; or (*c*) the constructed value. The latter closely resembles the cost-of-production criterion discussed earlier. The preeminent concept in dumping investigations and their determination is clearly fair value. It was certainly the intent of the Congress to give broad latitude to the investigating agency to define fair value and attendant procedures. This is surely a reflection of a recognition that the characteristics of production, marketing, and pricing vary a great deal from one commodity to another and the impossibility of anticipating the peculiar characteristics of any one commodity that might become the subject of a future investigation. An important corollary of the concept of fair value is that its definition should be consistent with normal business practice so that marketing and pricing practices considered "normal" for a particular commodity would not lead to a dumping finding.

Normal Business Practice for Perishable Agricultural Products

An understanding of the economics of production, marketing, and pricing of fresh vegetable commodities and the willingness to let this be reflected fully through the normal business practice doctrine was crucial in the Final Determination that Mexican vegetables had not been dumped in the U.S. market. If a substantially lesser role was given to economics—

and, therefore, a larger role for a literal application of the law—a finding of dumping most likely would have resulted.

The distinction between fixed and variable costs has important significance for highly perishable agricultural commodities. Because it is basically a biological process, agricultural production, once initiated, is largely beyond the control of the farmer. Maturity of the product means that the farmer has from a few weeks to a few hours, depending upon the commodity, to harvest it or suffer rapid deterioration in its economic value. The fresh vegetables at issue here can be harvested any week of the year somewhere in North America. Because of this continuous production, high storage costs relative to the value of the product, and the deterioration of the product when stored, it is not feasible to store fresh vegetables for more than a day or two. Under these circumstances, when the commodity is mature enough for normal harvest, the rational farmer looks at the prevailing price for the product; and if that price exceeds the variable harvesting and transfer costs, he must harvest and sell the product. Following this course, the farmer usually will recover all of his variable costs and at least a part of his fixed costs. Always waiting for a price that covers full costs of production will increase the likelihood of bankruptcy rather than continued survival of the firm.

Of all fresh vegetables and melons sold by U.S. farmers in 1977, potatoes ranked first in total value, lettuce ranked second, and tomatoes ranked third. Potatoes are relatively storable compared to lettuce and tomatoes, which can be stored for only a few days. Table 1 vividly illustrates that sales below full cost were common for California lettuce and Florida tomato growers over the ten-year period, 1968–78. The two California lettuce-producing districts are the largest in the United States. Florida's riper tomatoes are produced on stakes and trellises, to be harvested at a more advanced level of maturity. Florida's green tomatoes are grown without supporting devices and must be harvested in less mature condition.

Table 1 shows clearly that farmers do commonly harvest and sell their products at prices below full costs. Florida growers might say that the only reason for doing this is Mexican producers damage their markets. This explanation has little credence because below-cost sales are much more common for California lettuce, which has no Mexican competition in the U.S. or Canadian markets. It is also true that a higher proportion of Mexican tomato sales are riper tomatoes than is the case with Florida. Of the four combinations of area and commodity reported in the table, the one having the most direct and persistent competition from Mexico also has the lowest incidence of below-cost sales.

Table 2 shows that failure to recover full cost is common not only for week-long periods but also for entire production seasons and is independent of competition from Mexico. At the end of each production season, University of Florida researchers interview Florida vegetable producers to estimate total costs and sales revenues for each of the principal commodities. They treat the two types of tomato production separately. These two types of tomatoes and the other four vegetables (cucum-

Table 1. A Comparison of the Occurrence of Below-Full-Cost Sales of Tomatoes and Lettuce during 1968–78

Commodity	Total Weeks of Data	Total Weeks with Some Sales below Full Cost	Total Weeks with All Sales below Full Cost
		(%)	(%)
Riper tomatoes—Florida	162	20.4	1.2
Green tomatoes—Florida	185	36.2	14.6
District lettuce—Imperial Valley	151	68.2	30.5
District lettuce—Salinas-Watsonville	269	56.5	25.3

Source: Firch.

Table 2. A Comparison of Net Returns and Variability of Returns for Florida Vegetable Commodities with and without Competition from Mexico, 1968–78

	Six Vegetables with Mexican Competition[a]	Six Vegetables without Mexican Competition[b]
Total sales value 1977–78	$259,795,000	$236,054,000
Years of less than full-cost recovery	16 of 60	15 of 60
Weighted average: net returns per acre[c]	$249.50	$116.33
Standard deviation of net returns per acre[c]	$303.27	$201.41
Percent return on cost	10.8	11.1
Standard deviation of percent return on cost	15.0	18.9

Source: Firch.
[a] Lettuce, sweet corn, celery, potatoes, cabbage, and radishes.
[b] Two types of tomatoes, cucumbers, peppers, eggplants, and squash.
[c] Annual values adjusted to 1972 dollars using GNP Implicit Price Deflator.

bers, peppers, eggplants, and squash) are six commodities that compete with the controversial Mexican trade. For purposes of comparison, the six vegetables (lettuce, sweet corn, celery, potatoes, cabbage, and radishes) with the highest sales value but no Mexican competition were also studied (table 2).

The costs included in table 2 do not include management or capital costs in this very risky business activity. Therefore, in about one year out of four, Florida vegetable growers received no payment for their management skills and risks and also failed to cover other costs. There does not seem to be any significant difference in the frequency of net losses between the two groups of commodities. Tomatoes have both higher costs and higher sales revenue per acre. This largely explains the higher net returns per acre for the six commodities with Mexican competition. The average percentage of return is slightly lower for the commodities with Mexican competition, but these commodities have substantially lower variability of returns. Economic theory and observation strongly suggest that low average returns normally correlate with low variability of returns. The fact that standard deviations are larger than the average values indicates great profit variability and the relatively high probability of net losses in any given year.

Application of Tests for the Existence of Dumping

In the antidumping case examined here, the U.S. Treasury and Commerce Departments realized that the common test (i.e., foreign merchandise sold in the United States at a price below that of similar merchandise sold in the home market) could not be applied because the Mexican vegetables are produced with the sole intent of export. Thus, the Treasury and Commerce Departments chose to apply the third-country test rather than the constructed value (cost of production) test. The method used in applying the third-country test seems to satisfy the mandate of the law, but the economic interpretation of the findings can be judged only as ambiguous. That is, even though it was shown statistically that prices in Canada for fresh vegetables behave similarly to those in the United States, it cannot be inferred (without additional evidence) that dumping has not occurred.

A general observation of the market for fresh vegetables functioning at Nogales, Arizona (the U.S. port of entry for Mexican vegetables) suggests that there is no purely economic discrimination between U.S. and Canadian buyers. Brokers in Nogales representing Mexican growers try to get the highest possible price because their income is a direct function of sale price. Salaried buyers and brokers representing buyers in the United States and Canada work to get the lowest price they can for any given quality. With many buyers and sellers operating in this market, it is impossible for any systematic price differences between U.S. and Canadian buyers to exist after the effects of other relevant economic variables have been considered. In addition, it is difficult to imagine that price elas-

ticities for the commodities would be different between Canada and the United States. As figure 1 shows, differing price elasticities must exist for successful dumping to occur if subsidies are not given by the exporting country. Identical or similar per capita demand curves do not yield a price discrimination solution.

A crucial issue in applying the third-country test was whether actual below-cost sales should or could be included in the analysis. Exclusion of below-cost sales would reduce the number of available observations on Canadian sales, thereby jeopardizing the legitimacy of the third-country test. Excluding below-cost sales might also raise daily prices to Canadian buyers relative to prices to U.S. buyers, thereby increasing the probability that statistical tests would find significantly different prices in the U.S. and Canadian markets.

In its Final Determination, the government chose to confront this problem as follows:

> These standards would not require the disregarding of below-cost sales in every instance, for under normal business practice in both foreign countries and the United States, it is frequently necessary to sell obsolete or end-of-model year merchandise at less than cost. . . . Thus, infrequent sales at less than cost, or sales at prices which will permit recovery of all costs based on anticipated sales volume over a reasonable period of time would not be disregarded. . . . (U.S. Department of Commerce, p. 16)

The Commerce Department thus found ample basis for applying the normal business practice doctrine. This is consistent with the discussion in the previous section of this paper. Counsel for the Mexican interests submitted substantial material arguing that below-cost sales were a common and persistent practice, while counsel representing the Florida interests made no submissions on this issue even though, as shown, the same phenomenon occurs in the United States.

In its Final Determination, the Commerce Department stated: "The conclusion that there is no price discrimination between the U.S. and Canadian markets was tested by means of an F-test on regression analysis" (p. 19). It reiterated: "The results of the F-test performed on the regression show conclusively that there is no discrimination in the pricing of fresh winter vegetables sold in the U.S. compared with those sold in Canada" (p. 19). The Commerce Department gave further support for its conclusions by stating:

> Further, given the clear statistical evidence of the unitary nature of the markets and the absence of any barriers to the free flow of this merchandise across the U.S.-Canadian border, any sustained price discrimination in favor of U.S. buyers almost certainly would result in arbitrage (the reselling of merchandise by a U.S. buyer to a Canadian buyer for a profit). There is no evidence that any such practice occurs. (p. 19)

While the government may have amply demonstrated that the Mexican produce is sold at the same price to U.S. and Canadian buyers, thus fully satisfying the language of the law, two different economic conclusions are possible because Florida producers also supply about half of the Canadian purchases of fresh winter vegetables. On purely economic grounds, one could conclude that there is either no Mexican dumping in U.S. or Canadian markets or that there is dumping in both. The Final Determination does not provide the basis for determining which conclusion is correct. This casts doubt on the validity of the third-country test, especially when the United States is a substantial exporter to the same third country.

The cost-of-production test for the existence of dumping requires, in effect, that each sale price exceed the constructed value. The law and precedents of previous findings allow the constructed value to be only the full cost of production plus 8%. If this criterion had been used here, Mexico would have been found guilty of dumping. However, it is clearly a normal business practice for both Florida and Mexico producers to sell below full cost of production plus 8%.

The Commerce Department in its Final Determination stated that

> use of constructed value is not required by the 1979 Act, . . . expresses a general preference for the use of third country sales, rather than constructed value, where home market prices cannot be used. Furthermore, use of constructed value in this case would produce a result that manifestly disregards economic reality. . . . The use of a unitary price, such as constructed value, in circumstances such as those presented by this case would necessarily result in less than fair value sales even though sellers are acting in a normal, indeed in a necessary, way given the nature of the industry. Thus, use of constructed value would be inappropriate because it would require finding that an accepted, reasonable and economically necessary practice is unfair. (p. 22)

Because the Commerce Department apparently saw insufficient latitude to apply the normal business practice doctrine within the constructed value test, a conclusion reasonable on economic grounds could not be

reached. It then used a normal business practice argument to justify not using the constructed value test.

In the vegetable antidumping case, it is clear that, unless the Mexican government provides export subsidies and/or production subsidies, it is impossible for growers to sell continuously below cost.[2] Growers cannot use profits from domestic sales to support such an activity.

Other Available Data

To provide additional evidence on the dumping question, a regression trend analysis was applied to shipments of each of the five vegetables—tomatoes, peppers, cucumbers, squash, and eggplant—for every consecutive ten-year period from 1962–63 through the 1978–79 season. The results in table 3 provide insight into the relative success of the Florida and Mexico fresh winter vegetable industries in competing for the U.S. and Canadian markets over the seventeen seasons ending with the 1978–79 season. The interpretation of table 3 is, for example, that the total sales of tomatoes—from all sources during the winter season—increased at an average rate of 753,400 thirty-pound cartons per year during the period beginning with the fall of 1962 and ending with the spring of 1972. The asterisk following the 753.4 figure indicates a very low probability that the annual increase is really zero. A very high level of statistical reliability is associated with the measured trend.

The data show that the trend in total sales for each of the five vegetables has been positive throughout the period studied. Therefore, the competition between Florida and Mexico has occurred within an expanding total market. The competition would be much more severe if the total quantity absorbed by the market were either static or declining over time.[3] In addition, the trend values show clearly that the total quantity absorbed by the market for each of the five vegetables has not only been increasing over this seventeen-year period but has been increasing at an increasing rate. Over the 1969–79 period, the annual growth of combined Florida and Mexico shipments has increased at an annual rate of 4.2% for tomatoes, 7.8% for peppers, 5.9% for cucumbers, 13.4% for squash, and 7.3% for eggplant. These rates are substantial when compared with the growth in real U.S. total disposable income of 2.9% during the same period. Per capita consumption of most fresh fruits and vegetables produced in the United States has declined since 1950.

Consider the period 1969–79. Shipments of tomatoes, peppers, and eggplant from Florida increased substantially more than the respective shipments from Mexico. Cucumber shipments from Mexico increased slightly more than shipments from Florida, and shipments of squash from Mexico increased more than 40% over shipments from Florida. (Based on the total value of Florida's shipments of the five vegetables for the 1977–78 season, cucumbers represented less than 9% and squash less than 3% of the total.) Florida achieved this dominant competitive position in the third era despite unusually damaging cold weather during 1976–77 and 1977–78. On a total product weight basis, Florida captured 65% of the total market growth in the 1969–79 period. Shipment data for 1962–79 show clearly that, in the early part of this period, Mexico had a strong advantage which it effectively exploited as its industry rapidly expanded and Florida's declined. Toward the end of the 1962–79 period, however, Florida's shipments increased much more rapidly than Mexico's. Florida has been competing effectively with Mexico in recent years. To sustain dumping allegations in this relatively free market clearly would be inconsistent with the current competitive situation.

Conclusions

As this paper shows, the application of the antidumping laws to highly perishable commodities, such as fresh vegetables, presents formidable problems of economic analysis. The third-country test, as applied in this case, can lead to ambiguous results. The constructed value, or cost-of-production, test may lead to a finding of dumping even when foreign producers behave in a manner identical to U.S. producers whether or not import compe-

[2] The brief prepared for the Florida vegetable industry contended that excess profits were made by the Mexican producers during periods when the Florida producers had no, or very few, products for sale. Since this happened only during the freeze period, the increased earnings by Mexico are not excess profits resulting from a permanent monopoly.

[3] An examination of quantity data reveals that reported shipments by sources other than Florida and Mexico increased by extremely large proportions during the 1975–76 season for cucumbers and the 1976–77 season for tomatoes, peppers, and squash. In order to circumvent possible distortions in shipment data from other areas, trends were measured on only the combined shipments of Florida and Mexico.

Table 3. Changes in the Annual Trend of Shipments of Winter Vegetables for Selected Ten-Year Periods, Fall 1962 through Spring 1979

Vegetable	1962–72		1966–76		1969–79	
	(thousands of containers)					
Tomatoes						
Florida	702.8	(2.7)[a]	372.9	(34.8)	1,375.4	(*)
Mexico	1,509.6	(*)[b]	781.0	(6.8)	448.8	(28.1)
	806.8	(*)	1,153.8	(0.1)	1,824.1	(*)
Total	753.4	(*)	1,081.1	(0.1)	3,754.0	(0.1)
Peppers						
Florida	15.6	(86.5)	194.4	(13.9)	474.2	(*)
Mexico	355.3	(0.1)	319.3	(1.3)	244.4	(4.2)
	339.8	(0.2)	513.7	(0.1)	718.6	(*)
Total	374.8	(0.3)	626.0	(*)	1,214.5	(*)
Cucumbers[c]						
Florida	107.6	(2.6)	45.4	(44.4)	189.3	(*)
Mexico	355.6	(*)	221.0	(1.8)	203.2	(2.0)
	248.0	(*)	266.3	(0.1)	392.4	(*)
Total	278.7	(*)	558.6	(1.7)	805.2	(0.2)
Squash						
Florida	2.4	(84.0)	41.7	(3.8)	106.7	(*)
Mexico	70.5	(*)	60.5	(*)	152.5	(0.5)
	68.2	(*)	102.3	(*)	259.2	(*)
Total	39.5	(1.0)	100.9	(*)	427.3	(*)
Eggplant						
Florida	23.8	(10.2)	42.3	(7.0)	89.0	(*)
Mexico	92.8	(*)	93.6	(0.1)	50.7	(1.3)
	69.0	(0.1)	136.0	(*)	139.7	(*)
Total	68.4	(0.1)	134.2	(*)	176.5	(*)

Source: U.S. Department of Agriculture and Florida Department of Agriculture and Consumer Services.

[a] Figures in parentheses indicate the percentage of probability that the number immediately preceding it is not significantly different from zero; probability less than 0.05%.

[b] Asterisk indicates that the annual increase is not significantly different from zero.

[c] Total shipments of cucumbers for the 1967–68 season were adjusted because the published data showed the sum of Florida and Mexico to be more than total shipments. The adjustment assumed that areas other than Florida and Mexico shipped a quantity in 1967–68 that was on a linear trend of the 1962–72 period.

tition is present. It seems clear that the Congress did not intend for the latter to occur.

What are the appropriate solutions to this apparent incompatability of the law and economics? The law should be changed. Either perishable agricultural commodities should be exempted from the law or the law should be changed to allow the application of more sophisticated economic and statistical analyses. The models used should have the capability to distinguish between normal and abnormal behavior of foreign producers, the behavior of U.S. producers being standard. In the current law, exporters of perishable agricultural products have a difficult time defending themselves in antidumping suits if the cost-of-production criterion is used to determine fair market value. A normal business practice concept should be explicitly incorporated into law for perishable agricultural products. Supporting this concept indirectly, as the U.S. Department of Commerce seems to have done under the third-market test, has little economic justification. However, it is clear that, given the current law, such a strategy is sensible for the U.S. government if it wants to pursue trade liberalization with Mexico.

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Simulating the Impacts of Credit Policy and Fertilizer Subsidy on Central Luzon Rice Farms, the Philippines

Mark W. Rosegrant and Robert W. Herdt

The effects of credit policy and fertilizer subsidy on farmers' input choices, production, and income are examined with a multiseason decision-making model. Stochastic production technology, risk-neutral and risk-averse decision rules, short-term savings/consumption behavior, and a dual financial market are considered. Results indicate the risk-neutral rule is more consistent with actual choices than risk-averse rules. Estimated yields increased 21% to 30% from joint credit and fertilizer subsidies. Benefits are greater on irrigated than on rainfed farms. A substantial default rate in the institutional market reduces credit program benefits.

Key words: credit policy, fertilizer subsidy, Philippines, rice, risk aversion, simulation.

Credit and fertilizer subsidies are used by policy makers in many developing countries, including the Philippines. Their effects on farmer choice of inputs, production, and income on mono-crop rice farms in Central Luzon are examined in this paper. Prior to 1973/74, few Philippine rice farmers had access to institutional credit, primarily because of high collateral requirements imposed by private banks (Sacay). A series of typhoons in 1972 reduced the rice crop by 16% over the previous three-year average, and during the same year (1972) the entire country was brought under a land reform program that was expected to restrict severely the credit traditionally provided by landlords to share-tenants. Attempting to boost rice production, the government increased the flow of low-cost credit to rice farmers in 1973/74 through a program called Masagana 99 (World Bank, chaps. 6, 7).

During Masagana 99's initial year, farmers were allowed to borrow up to 900 pesos per hectare (P/ha) per six-month season. In 1974/75 the loan limit was increased to P1,200/ha (P7.30 = US$1.00 between 1973 and 1979). These production loans are available at an effective interest rate, including service charges and discounting, of approximately 16% per year. In 1974/75, over 40% of national rice area was financed under Masagana 99, but financing declined to about 10% in 1977/78. A major cause of this decrease was the frequency of defaults on Masagana loans, disqualifying farmers from further borrowing under the program.

The primary alternative source of production loans is the informal financial market. Credit availability in this sector varies, but surveys conducted by the International Rice Research Institute (IRRI) indicate a range of effective credit ceilings of P300–P600/ha in Central Luzon. Informal market interest rates vary from 30% to 100%, with average rates of 45% to 50% (Rosegrant 1978, Manto and Torres).

The Philippine government also has subsidized fertilizer prices. A two-tier fertilizer-pricing system was established in 1973, when fertilizer supplies in the international market were growing tight and world prices were increasing rapidly. A subsidized price was established for rice and other food crops, with a higher price for export crops, set to reflect import and marketing costs. This system continued until 1975/76, after which a uniform, subsidized price applied to all crops (table 1).

Rice production increased at more than 5%

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Table 1. Prices of Nitrogen and Phosphorus Fertilizer (P/kg) for Rice and Export Crops and Subsidies, Philippines

Crop Year	Price for Rice Production		Price for Export Crops		Rice Production Subsidy[a]	
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
1973/74	2.15	2.56	3.82	4.22	1.67	1.66
1974/75	4.38	3.83	7.07	6.48	2.69	2.65
1975/76	3.97	3.84	6.24	6.34	2.27	2.50
1976/77	3.68	4.09	3.68	4.09	0.72	1.21
1977/78	3.68	4.09	3.68	4.09	0.22	0.51

Source: Fertilizer and Pesticide Authority, Republic of the Philippines.
[a] Equal to the difference between the price for rice production and for export crops 1973/74 to 1975/76; equal to import plus marketing costs less sale price for 1976/77 and 1977/78.

per year in the Philippines during the 1970s (U.S. Department of Agriculture [USDA]). Obviously, many factors contributed; an important question is the contribution of credit and fertilizer subsidies. Evaluation of these policy instruments can be either normative or positive. Comparison of credit program participants with nonparticipants in three Luzon provinces shows that the former borrowed roughly twice as much and spent about 50% more on rice production inputs than the latter (Herdt and Rosegrant). However, the relatively small samples studied and the effects of differences in weather, quality of irrigation, and technology prevent one from causally linking the policies with the observed differences. Also such comparisons cannot separate the effects of credit from fertilizer subsidies. Modeling the decision process within a normative framework is an alternative that meets these objectives.

The normative framework is a multiseason model incorporating stochastic production technology, risk-neutral and risk-averse decision rules, short-term savings/consumption behavior, and a dual financial market with institutional and informal sectors. Systematic behavioral assumptions govern allocation of funds within the model.

A problem with modeling credit use is that fungibility of credit permits program funds to be diverted from their intended purpose into other enterprises or consumption (Von Pischke and Adams). Diversion to alternative enterprises is a minor problem in the Central Luzon area of this analysis—IRRI farm surveys show that rice occupied 88% of the total cropped land of rice farmers in 1979, and that livestock enterprises were minimal.[1] Some diversion to consumption probably does occur despite the dispersion of credit in the form of chits redeemable in kind. However, credit regulations make this difficult to detect.

Between 1973/74 and 1975/76, rice farmers could have sold fertilizer intended for rice to the unsubsidized sugar sector, but this opportunity was limited by the small area planted to sugar in Central Luzon. Following termination of the two-tier price system, there was little opportunity for arbitrage. Adequate supplies of fertilizer were available at prevailing prices. Thus, the model estimates an upper limit of the likely production impact and provides a basis for separating the impact of fertilizer subsidies from credit subsidies.

The Model of Farmer Decision Making

Previous microlevel analyses of the impact of credit policy on farm decision making have utilized mathematical programming models (Naseem, Ladman, and Whitaker). The Ladman and Whitaker models are static, one-period models; all three models have deterministic production relationships and a single credit market. The dynamic model presented here incorporates stochastic production relationships and a dual credit market that is characteristic of rural areas in the Philippines and most developing countries.

Operation of the Model

The flow chart in figure 1 outlines the model. Initially, output and input prices and initial

[1] Rice farm labor income accounted for 90% of farm earnings and 75% of household labor earnings in another study conducted in three rice-growing municipalities of Central Luzon in 1974 (Guino). Still another study showed that in 1978 rice provided 85% of farm income in Laguna province of Luzon (Smith and Gascon).

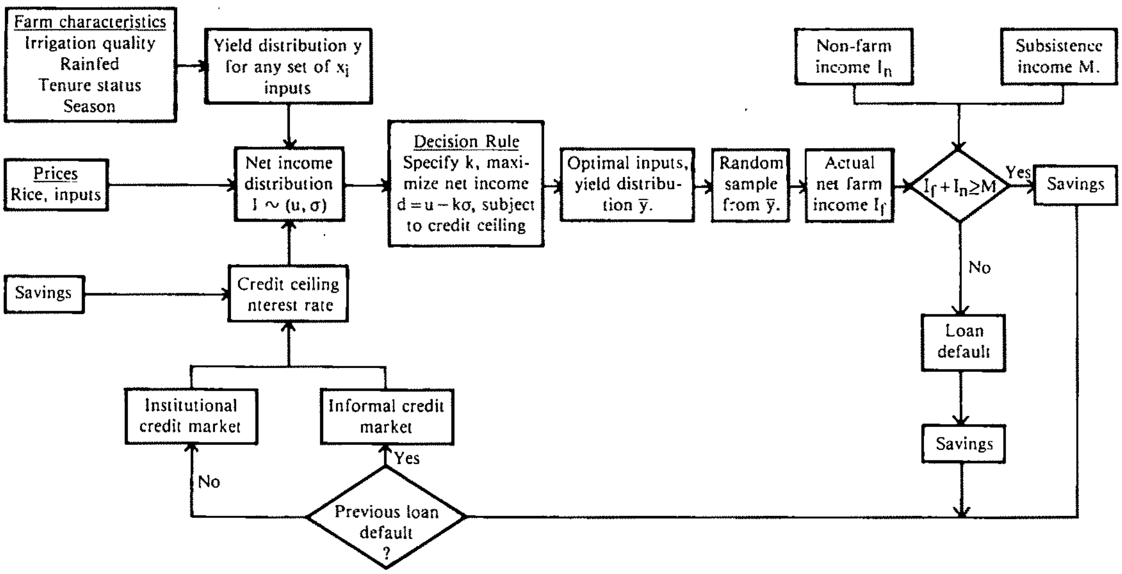

Figure 1. Flow chart of farm decision-making model

savings are set and farm characteristics specified to determine a yield distribution for any set of inputs. The financial market in which the farm borrows determines its interest rate and credit ceiling. The net income distribution for any input level can then be computed and optimal input levels chosen by the specified decision rule, subject to the credit ceiling.

The actual yield is generated by random sampling from the yield distribution corresponding to the optimal input level, and actual net income is computed. If net income plus nonfarm income is greater than subsistence requirements, savings are carried forward to the next season to begin another iteration. If total income is less than subsistence, the farm defaults on its loan and, if necessary, borrows from the informal credit market to cover subsistence requirements. Savings is computed, and the next iteration begins with the farm denied access to the institutional market because of default. If total income exceeds subsistence requirements, the farm remains in the institutional market and begins the next iteration.

To solve the model for mean input use, yield, and income over several seasons, the decision/outcome process is represented as a finite Markov chain process (Chung, Feller). The states $a_1, a_2, \ldots, a_m$ in the Markov process are determined by savings level and financial market access. Any state a_i determines input choice when the decision rule is specified and parameter values (such as rice price and input costs) are set. Input choice implies a yield distribution, which is used to compute the row of transition probabilities p_{ij}, $j = 1, \ldots, m$ of moving from state a_i at the start of one season to a_j at the start of the following season. Computation of transition probabilities for all a_i provides the Markov transition matrix. Specification of the distribution of farms across states in the initial season then permits solution of the model for the mean values of input use, yield, and income in any subsequent season.

Farm Characteristics

Farms are differentiated by tenure status (fixed or sharecrop rent), irrigation quality, seepage and percolation rates, and season of operation. The latter three define a water regime. The water regime determines the distribution of moisture stress in the production function (described below), thereby determining the frequency distribution of yield for any input level.

Prices

The prices of rice and the inputs (nitrogen, phosphorus, insecticide, and herbicide) can be set in the model to represent any desired policy mix. Actual prices of nitrogen and phosphorus are jointly determined by the prices of major fertilizer products containing these nutrients. This is reflected in the model by con-

straining the ratio of nitrogen to phosphorus at 2:1.

Decision Rules

Decision rules which have been utilized in modeling farmer behavior have been reviewed elsewhere (Anderson). A safety-first rule, to maximize the net returns which can be obtained with a fixed confidence level, is used here because it permits consistent specification of a range of attitudes toward risk (Dillon and Scandizzo, Moscardi and de Janvry, Roumasset). When the shape of the net income distribution is known, the decision rule is to maximize d, where $d = u - k\sigma$, and u is expected net income, σ is the standard deviation of net income, and k is the risk-aversion coefficient.

The coefficient k specifies the safety-first confidence level, or level of probability along the cumulative distribution of net income. For a given distribution, the larger the value of k, the greater the degree of risk aversion. If $k = 0$, the decision rule is risk neutral.

Income Allocation

Income is allocated between consumption and savings. Levels of subsistence consumption and nonfarm income are set, and income allocation behavior is specified as a marginal propensity to consume out of income in excess of subsistence consumption requirements:

$$\begin{aligned} I_t &= I_f + I_n, \\ C &= M + a(I_t - M), \\ S_t &= S_r + I_t - C, \end{aligned}$$

subject to $I_t \geq M$, where I_t is total income, I_f is farm income, I_n is nonfarm income, C is consumption, M is the subsistence consumption level, a is the marginal propensity to consume, S_t is total savings carried forward to the following production season, and S_r is savings from the previous season retained after purchase of inputs.

When total income is less than subsistence consumption, the constraint is not met, and consumption cannot be determined by the relationship above. In order to make up the consumption deficit and meet subsistence consumption requirements, the farmer fails to repay either all or part of any production loan he has obtained. Deficit-reducing behavior is determined in the financial market.

Financial Market

Farms face a capital constraint set by the level of internally generated savings and by the availability of credit from the financial market. Total spending on fixed and variable costs in a given season cannot exceed savings brought forward plus new borrowing. The maximum amount of credit available and its cost can be set within the model to reflect any desired credit policy.

Money can be borrowed from either institutional lenders or informal money lenders. All farms begin the first season with access to the institutional market for credit at a specified interest rate up to a maximum loan limit. The farm continues to borrow from the institutional market unless, because of low production caused by stochastic events, it can no longer both repay the loan and meet subsistence requirements. When this occurs, the farm defaults on its institutional loan and supplements consumption with the proceeds from the loan default up to the subsistence consumption level, allocating any additional funds between consumption and savings. If proceeds from the loan default are not sufficient to make up the difference between income and subsistence consumption, the farm borrows from the informal credit market, the farm's only other source of credit.

When the farm is in the informal market, the method for meeting subsistence requirements reflects the better enforcement of repayment and lack of alternative funding sources. In case of low production, the farmer only delays payment on the proportion of the production loan needed to achieve the minimum consumption. No additional consumption is allowed, and no savings are generated. The portion of the loan on which payment is delayed is carried over to the next season and repaid from income, along with any new production loan taken out at the beginning of the next season.

Production Function and Yield Distributions

At the core of the model are the frequency distributions of yield estimated from a highly disaggregated production function incorporating managed inputs and environmental variables. The production function is of the form:

$$y = f(x_i, v_j, q_r),$$

where $i = 1, \ldots, s; j = 1, \ldots, n; r = 1, \ldots, p$; y is yield; x_i are managed inputs (nitrogen, phosphorus, insecticide, and weed treatment); v_j are stochastic variables (solar radiation, stress days, and insect infestation index) not under farmer control and of unknown value at the time of the decision about the x_i; and q_r are variables not under farmer control but with known values (clay content). Table 2 shows the production function estimated from 674 observations taken from response experiments in farmers' fields in Central Luzon in two wet and two dry seasons. In these experiments, inputs not included in the production function were held at levels comparable to actual farm practices in the area.

The independent variables explain 72% of the variation in yields, and all variables are significant at the 0.01 level except for insecticide, which is significant at the 0.05 level.[2] Both insect infestation and insecticides are included because the usual practice is to apply insecticide after initial infestation. Labor is not included in the production function because it was held constant in the experimental plots except for that associated with applying the specified managed inputs. Labor is therefore a direct function of managed inputs.

Typhoon damage, the most important stochastic variable left out of the production function, was excluded because no typhoon damage was experienced on the experimental plots. In order to account for the impact of typhoon on yield variability, the production function was adjusted using a typhoon damage index computed from farmers' subjective estimates:

$$y' = (1 - t)\, f(x_i, v_j, q_r),$$

where t is the percentage yield loss from typhoons.

Given a production function of this form, the frequency distribution of y' for any x_i, q_r can be estimated from the joint frequency distribution of the stochastic variables t, v_j (Anderson, Dillon, Hardaker; de Janvry; Byerlee and Anderson). Lack of information about the conditional distributions of the stochastic variables precludes analytical solution of the joint frequency distribution of the variables. However, if it is assumed that the stochastic variables are independently distributed, a discrete approximation of the frequency distribution of y' for any x_i and q_r can be obtained by repetitively sampling from the frequency distributions of t and v_j and then computing point estimates of y' from the production function.[3] With sufficient iterations, 1,000 in this case, stable estimates of the moments of the distrubution of y' can be obtained and continuous frequency distributions fit using Pearson's system (Day, Elderton and Johnson).

In order to estimate the yield distributions, frequency distributions were estimated for solar radiation, insect damage, typhoon damage, and stress days, the latter under a range of water regimes representing different qualities of irrigation and drainage.

Solar radiation distributions were estimated from 1966–75 data drawn from research station records in Central Luzon. The frequency

Table 2. Yield Response Function for Modern Rice Varieties in the Philippines (kg/ha)

Variable	Regression Coefficient	t-value
Intercept	1079.83*[a]	7.86
Nitrogen x solar radiation[b]	0.91*	12.75
Nitrogen squared	−0.06*	−5.98
Stress days[c]	110.68*	6.70
Phosphorus (kg/ha)	3.81*	4.12
Weeding dummy 1[d]	160.11	2.68
Weeding dummy 2[e]	297.94*	5.30
Insect infestation index (% infestation)	−7.87*	−3.23
Insecticide (P)	1.47**	2.12
Percentage of clay	28.40*	11.83
Nitrogen x stress	−0.39*	−5.06
Solar radiation x stress	−8.95	−9.47
R^2 adjusted	0.72	

Source: Wickham, Barker, Rosegrant, p. 226.
[a] Single asterisk means coefficient significant at 0.01 level; double asterisk means coefficient significant at 0.05 level.
[b] Solar radiation measured in kilocalories/cm² during the period 45 days before harvest to harvest.
[c] From 60 days after transplanting to 20 days before harvest.
[d] One application of herbicide.
[e] One application of herbicide plus one handweeding.

[2] Multicollinearity is a potential problem in the production function since some variables appear in more than one term and some of the independent variables (nitrogen x solar radiation and nitrogen squared, stress days and nitrogen x stress, and stress days and solar radiation x stress) are highly correlated. However, multicollinearity is not harmful unless it causes high standard errors and lack of significance in the regression coefficients (Kmenta, Johnston). This is not the case here.

[3] The independence assumption appears reasonable. Regressions among solar radiation, stress days, and insect damage using the response function data resulted in insignificant coefficients and R^2s of 0.08 or less. The typhoon damage distribution was computed using a 1975 IRRI farm survey. Using this data, regressions among typhoon damage, drought damage (a proxy for stress), insect damage estimates, and solar radiation gave insignificant coefficients and a maximum R^2 of .11.

distribution for the insect infestation index was computed from the 674 observations over the four seasons from which the production function was estimated. The typhoon damage index was computed from farmers' estimates of typhoon damage over five crop years in Central Luzon.

A water balance model was used to generate frequency distributions of stress days for good, average, and poor irrigated sites and for rain-fed conditions, each with high, medium, and low seepage and percolation rates. The water balance model simulates weekly irrigation and rainfall. It is based on sampling from distributions of irrigation flows for sites in Central Luzon and from the distribution of rainfall recorded at Cabanatuan City, Nueva Ecija, 1949–74. Stress days are computed as a function of weekly water flows and losses from the site. Repeated iteration of the model produces a stable estimate of the distribution of stress days for any quality of irrigation and soil type (Rosegrant 1976, 1978; Wickham, Barker, Rosegrant; Wickham).

In the wet season, maximum expected yields and their standard deviations are similar for all qualities of irrigation, while rain-fed maximum expected yields are 13% lower (table 3). In the dry season, the difference between maximum yields with low and high quality irrigation is 1.3 t/ha. High quality irrigation reduces the standard deviation of yields by 30%.

The Impact of Risk Aversion

The importance of risk aversion for farmer input choices is the subject of continuing debate. Binswanger (using an experimental gambling approach with real payoffs) found attitudes highly concentrated at intermediate or moderate risk aversion. Dillon and Scandizzo (using mental experiments) report values of the risk-aversion coefficient k (from the decision rule, maximize $d = u - k\sigma$) ranging from -0.6 to 1.8, with a mean of 0.9. About 30% of their sample farmers were highly risk averse ($k > 1.5$). Neither study assessed risk attitudes in actual production decisions.

Moscardi and de Janvry estimated a corn production function, and computed the value of k which would account for the difference between actual nitrogen use and the expected income-maximizing level. The mean value of k is 1.12 with a range of 0.0 to 2.0 and a high concentration of strong risk aversion ($k > 1.2$). However, their production function did not include environmental variables such as solar radiation and moisture stress. In addition, their assumption that risk explains all the shortfall from optimal nitrogen use ignores the possible impact of constraints such as limited credit.

Roumasset explains actual nitrogen use of two samples of Philippine rice farmers using risk-neutral and risk-averse decision rules with a production function adjusted for major losses. He finds that the risk-neutral decision rule explains actual nitrogen use better than risk-averse rules.

To test the impact of risk aversion in this model, alternative decision rules were defined by specifying the risk-aversion coefficient k. Risk-neutral, moderate risk-averse, and strong risk-averse rules were tested. In the neutral case, $k = 0.0$. In the moderate case, k was set to maximize net income with probability of 0.20 on the cumulative frequency distribution of net income. The strong risk-averse rule maximizes the net income with probability 0.10 on the cumulative distribution.

Because the yield distributions, and therefore the net income distributions, have different shapes for different farm types, the value of k which specifies a given confidence level on the cumulative distribution also varies. For moderate risk aversion, k has a range of 0.62 to 0.94, with a mean value of 0.80. In the strong risk-averse case, k has a mean of 1.44 and a range of 1.34 to 1.53.

Comparison of model results with actual input use and yields suggests that the risk-neutral assumption better explains input choices than risk aversion. Model parameters,

Table 3. Yield-Maximizing Nitrogen Level, Maximum Expected Yield, and Standard Deviation of Yield, Three Qualities of Irrigation, from Estimated Yield Distributions

Season	Irrigation Quality	Yield-Maximizing Nitrogen (kg/ha)	Maximum Expected Yield (kg/ha)	Standard Deviation of Yield (kg/ha)
Dry	High	152	3,747	555
Dry	Medium	140	3,092	704
Dry	Low	124	2,455	781
Wet	High	128	2,977	833
Wet	Medium	124	2,972	828
Wet	Low	124	2,958	828
Wet	Rainfed	112	2,592	794

Note: Other inputs set at high levels: 60 kg/ha phosphorus, 2 applications of insecticide, 1 application of herbicide, and 1 hand-weeding; average soil quality.

such as prices, costs, credit ceilings, and sharing rates, were set at mean or representative values for Central Luzon, 1971/72–1977/78. The model was run for nine years (18 crop seasons), generating a distribution of farms between institutional and informal credit markets comparable to the actual distribution in Central Luzon, 1971/72–1977/78.[4]

The strong risk-averse rule generates input use and yields far below the actual levels for both irrigated and rain-fed farms (table 4). Moderate risk aversion is relatively consistent with actual results only for irrigated farm nitrogen use with the P600/ha informal loan ceiling. In all other instances, the moderate risk-averse rule produces input choices and yields considerably lower than the actual levels. Hence, the risk-neutral rule is used to examine credit and fertilizer subsidies.

The Impact of Credit and Fertilizer Policy

A subsidized credit program with increased loan ceilings, similar to those under Masagana 99, and a fertilizer subsidy comparable to that of the Philippine government were evaluated for crop years 1973/74 (the first year of Masagana 99) through 1977/78. Model parameters such as farm size, nonfarm income, wages, rents, herbicide and insecticide prices, and sharing rates were set at representative values for Central Luzon. Farm prices of rice were set at their annual prevailing level.

Fertilizer prices were set for successive runs of the model at the annual subsidized and unsubsidized rates derived from table 1. Financial market variables were set to simulate the presence or absence of a Masagana-type credit program. For model runs simulating existence of a credit program, all farms were assumed to begin in the institutional market, with a loan ceiling of P1,200/ha and an interest rate of 16% per year. The farms continue to borrow in the institutional market until default, after which they enter the informal market.

Interest rates in the informal market were set at 48% per year with maximum loan limits at P300/ha and P600/ha for alternative runs. For model runs simulating the absence of a subsidized credit program, all farms were assumed to borrow only from the informal market.

Three policies were evaluated: both the credit program and the fertilizer subsidy, the credit program with no fertilizer subsidy, and fertilizer subsidy with no credit program. In each case, the estimated impact of the policies is compared with the case of no government intervention; that is, with no credit program and no fertilizer price subsidy.

[4] Reported results are aggregated across 42 farm types: 9 irrigated types operating in wet season only plus 9 irrigated types operating in both wet and dry season plus 3 rain-fed wet season types, each then stratified by tenure status (fixed payment, share tenancy). Results are weighted by the estimated area distribution of these farm types in Central Luzon. The results are not sensitive to moderate shifts in the area distribution (Rosegrant 1978).

Table 4. Actual and Simulated Mean Input Use and Yields for Modern Varieties, Central Luzon, 1971/72 to 1977/78

		Informal Market Loan Ceiling					
		Nitrogen (kg/ha)		Other Inputs (P/ha)[a]		Yield (kg/ha)	
Decision Rule	Farm Type	300	600	300	600	300	600
Actual[b]	Irrigated	57		251		2,437	
Actual	Rain-fed	38		172		1,753	
Model results							
Risk neutral	Irrigated	54	67	227	281	2,216	2,429
Risk neutral	Rain-fed	37	42	166	208	1,745	1,897
Risk averse							
Moderate	Irrigated	44	53	158	178	2,085	2,163
Moderate	Rain-fed	24	29	110	121	1,575	1,610
Risk averse							
Strong	Irrigated	28	35	124	135	1,910	1,973
Strong	Rain-fed	9	9	80	80	1,412	1,412

[a] Phosphorus, insecticide, herbicide, and weeding labor.
[b] Yields from the Bureau of Agricultural Economics. Input levels computed from five International Rice Research Institute surveys, two Bureau of Agricultural Economics surveys, and two Department of Agriculture (Special Studies Division) surveys.

Combined Credit Program and Fertilizer Subsidy

The combined impact of the credit program and fertilizer subsidy is large with either informal credit market loan limit (table 5). With a P300/ha loan limit in the informal market, the combined credit program and fertilizer subsidy is estimated to increase the average nitrogen use on irrigated and rain-fed farms by 43 kg/ha, other input use by P129/ha, yields by 510 kg/ha (30%), and income by P131/ha (29%). For the P600/ha informal market loan ceiling, the estimated combined impact is reduced, but still impressive: average increases of 38 kg/ha in nitrogen use, P90/ha in other inputs, 393 kg/ha (21%) in yields, and P118/ha (25%) in income.

Irrigated farms are considerably more responsive to combined credit and fertilizer policies than rain-fed farms. They also gain higher benefits. The reasons for their higher responsiveness are to be seen in the separate effects of the credit program and fertilizer subsidy.

Credit Policy

The credit program alone produces substantial gains for irrigated farms but considerably lower benefits for rain-fed farms. For the P300/ha case, for example, irrigated farms increase yields by 22% and income by 14% due

Table 5. Estimated Increases in Input Use, Yield, and Income Due to Credit Program and Fertilizer Subsidy, 1973/74 to 1977/78

Policy	Farm Type	Nitrogen (kg/ha)	Other Inputs (P/ha)	Yield (kg/ha)	Income (P/ha)
		Informal Market Loan Limit of P300/ha[a]			
Credit program with fertilizer subsidy	Irrigated	49	162	619	158
	Rain-fed	30	69	308	81
	Average[b]	43	129	510	131
Credit program, no fertilizer subsidy	Irrigated	22	127	397	67
	Rain-fed	7	41	114	34
	Average[b]	17	103	298	56
Fertilizer subsidy, no credit program	Irrigated	14	−13	106	55
	Rain-fed	14	− 5	102	38
	Average[b]	14	−10	105	49
		Informal Market Loan Limit of P600/ha[a]			
Credit program with fertilizer subsidy	Irrigated	42	115	466	142
	Rain-fed	30	45	257	74
	Average[b]	38	90	393	118
Credit program, no fertilizer subsidy	Irrigated	13	78	221	49
	Rain-fed	6	12	50	28
	Average[b]	10	54	127	35
Fertilizer subsidy, no credit program	Irrigated	30	47	311	85
	Rain-fed	6	33	207	39
	Average[b]	27	35	274	69

[a] Estimated increases are computed relative to case of no credit program and no fertilizer subsidy.
[b] Average of irrigated and rain-fed farms, weighted by area harvested in Central Luzon.

to implementation of a credit program without fertilizer subsidy, while the yield and income benefits for rain-fed farms are 7% and 9%, respectively.

Irrigated farms gain higher benefits from a credit program that releases a binding credit constraint because they can utilize higher input levels more profitably than rain-fed farms. Lower moisture stress in both seasons, and the high solar radiation and lack of typhoons in the dry season increase the marginal productivity and optimal level of nitrogen and other inputs on irrigated farms, leading to larger benefits than on rain-fed farms.

Additional runs were made to estimate the impact of reducing interest rates from 48% to 16% without increasing the availability of credit. The independent impact of such a reduction in interest rate is relatively modest: an average increase for irrigated and rain-fed farms of 5 kg/ha in nitrogen, 3% in yields, and 6% in income with the P600/ha loan limit, and 3 kg/ha nitrogen, 2% in yield, and 3% in income with the P300/ha loan limit.

The maximum interest rate impact occurs when credit is not constraining, so farmers can respond fully to price. Sensitivity tests using the model with no credit constraint show a maximum increase in yields of 5% and in incomes of 10% caused by a reduction in the interest rate from 48% to 16%. When the credit ceiling is binding, price changes are not effective. Instead, an interest rate reduction works by increasing the amount of inputs which can be financed for a given amount of credit by increasing income and savings available to finance inputs. This effect is smaller than the price impact, and causes a reduced interest rate effect when a binding loan constraint holds for some or all farms.

Default Rates

The model predicts average annual default rates on institutional market loans of 9.7% with the fertilizer subsidy and 10.6% without. As of the 1977/78 crop year in the simulated credit program, only 66% of the farmers were eligible for institutional credit in the subsidized fertilizer case and 63% in the unsubsidized fertilizer case. With a P300/ha informal market loan limit, the average yield loss due to default in 1977/78 was 8% and income was reduced by 6%. For the P600/ha informal loan limit case, the reductions in benefits due to default were approximately half as large.

Fertilizer Subsidy

The separate impact of a fertilizer subsidy in the absence of a credit program is highly dependent on the availability of credit in the informal market. With the P300/ha loan limit (which is binding on most farms), the decrease in the price of fertilizer (due to the subsidy) permits 14 kg/ha more fertilizer to be used by increasing the amount financed within the loan limit. Other input use decreases by P10/ha because a small amount of the other inputs are replaced by fertilizer which, because of the subsidy, becomes relatively more profitable. The net yield benefits of the fertilizer subsidy are 6%, with incomes increasing by 11%. Irrigated and rain-fed farms get approximately the same benefits.

With the P600/ha informal credit limit (which is nonbinding on many farms), the fertilizer subsidy boosts fertilizer use through the price impact, increasing marginal returns and optimal fertilizer levels. It also permits more fertilizer to be financed through loans. The impact of the subsidy on fertilizer use is nearly double that of the P300/ha loan limit case. With the higher loan limit, irrigated farms get 50% higher yield benefits and double the income benefits of rain-fed farms due to the higher productivity of fertilizer on irrigated farms.

Conclusions and Implications

Following the very poor harvest of 1972/73, the Philippine government instituted subsidized credit and fertilizer policies. Between 1972/73 and 1977/78, Phillipine rice production increased by 56% and rice yields increased by 38% (USDA)—an outstanding achievement, but one which could not be attributed only to government credit and fertilizer policies. Our analysis, using a dynamic model of farmer decision making, shows that credit and fertilizer policies could have induced at most a yield increase of 21%–30% for a set of farms representative of those in Central Luzon. The model correctly projected relatively large default rates from the government credit program. These occur because subsistence consumption has priority over loan repayment in years of low production caused by unfavorable weather and pest infestations. Assuming a risk-averse, safety-first decision rule resulted in poorer model validation than the alternative risk-neutral profit-maximizing behavioral rule.

The impact of a credit program that reduces interest rates and increases credit limits is larger when credit availability in the informal market is lower. The greatest impact of the credit program is in releasing the credit constraint; the independent impact of interest rate reduction is small. This confirms Adams' suggestion that higher interest rates, if they attract substantially more funds into rural financial markets, would be preferable to subsidized low interest rates and would not likely reduce production significantly.

The substantial default rate on institutional market loans causes a major reduction in long-term benefits of the credit program, reducing the number of farms with access to the institutional credit market. These defaults also reduce the effectiveness of the fertilizer subsidy since its impact increases as the availability of credit increases.

When the informal market loan limit is P300/ha, the fertilizer subsidy alone contributes less than 20% of the total yield increase attributable to the joint credit/fertilizer program. With an increase in informal market credit availability to P600/ha, the yield benefits of fertilizer subsidy alone expand to 70% of combined program benefits, even with the high interest rate in the informal market. This confirms the importance of increasing the quantity of credit to farmers so that they can utilize yield-increasing inputs.

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Recreational Demands for Maintaining Instream Flows: A Contingent Valuation Approach

John T. Daubert and Robert A. Young

Recreational uses of streams, although nonconsumptive, increasingly conflict with traditional off-stream uses of water in arid regions. Recreational demands for instream flows have collective good attributes such that the recreationists' preferences may be inadequately reflected in water allocation decisions. The contingent valuation approach was adapted to impute instream flow shadow prices from a sample of recreationists on the Cache la Poudre River in northern Colorado. During periods of relatively low flows, the estimated instream flow marginal value exceeds the marginal value of water in irrigation, suggesting a need for altered water allocation policies.

Key words: contingent valuation, instream flows, public good demands, water-based recreation.

Rapidly growing demands for recreational activities using free-flowing streams have encouraged public policies to preserve or enhance instream flows. Congress approved the Wild and Scenic Rivers Act, and several western states have adopted programs to protect or increase water allocations for recreational demands. In the arid western United States, any program to maintain instream flows is potentially controversial, because it usually conflicts with existing or planned diversions for irrigation, cities, or industries. Off-stream diversion or storage of water may severely reduce flows during some periods, thereby reducing the potential quality of recreational experiences. Economics has made little contribution to the resolution of such conflicts, and most streamflow maintenance policies have been based on physical and biological criteria.

Instream flows are not subject to the same economic forces as those affecting off-stream allocations. Off-stream uses are typically for private, intermediate good production. In contrast, instream flows appear as "free goods" in relation to alternative uses. Changes in flow, affecting the stream's ability to support recreation, generate collective benefits or costs which reflect nonrivalry in consumption. Once instream flows are provided, anyone visiting the stream can enjoy the recreation experience. Even though any individual's willingness to pay for incremental changes in the flow level may be small, the aggregate benefit over large numbers of users could be large enough to warrant reallocation of water toward instream flow, away from withdrawal uses.

In resolving allocation problems, water managers are often more responsive to the tangible market-like data which reflect intermediate good demands. Relatively accurate information is available on the marginal value of water in withdrawal uses (see Young and Gray). However, measuring economic benefits from alternative flow levels is a different problem. Water managers relying only on market-related information will allocate insufficient water into recreational activities.

A workable method to measure the economic value of water left in the stream will help water managers formulate policies and

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regulations for allocating water between instream and off-stream uses. The objective of our research was to develop and test such a method. We estimated the total and marginal willingness to pay for instream flow. The results were derived from a contingent valuation survey of three activities on a Colorado mountain stream—trout fishing, white-water boating (with kayaks, rafts, etc.), and streamside recreation (picnicking, camping, and hiking).

Earlier attempts to deal with this problem focused on measuring benefits associated with a specific recreation activity or site (Hyra). However, water managers need information about the value of water separate from the value of the related activity. Because efficient allocation among uses requires that marginal benefits of water in each use be equal, we formulated our research to estimate directly the recreationist's marginal economic value of instream flow. The measure of economic benefits is designed to be comparable with values in withdrawal uses.

Concepts and Procedures

Withdrawal and instream water uses compete for water on all of Colorado's rivers. The conflicts are typified on the Cache la Poudre River in the mountains of northwestern Colorado, a popular recreation area. During spring and early summer when the stream runoff is high, the river provides excellent white-water rapids for kayakers and rafters. The Poudre River, with its temperature, turbidity, and flow attributes, is an excellent trout fishery. More than 100,000 user days are experienced annually by recreationists visiting the canyon.

Stream flows have been diverted from the Poudre River for irrigation since 1864. Irrigation districts, by adding to or withdrawing from mountain reservoirs, can significantly raise or lower instream flows in the canyon. Up to now, such decisions have been made with little reference to recreation activities.

Concepts

Two basic approaches can determine the economic benefits of nonpriced environmental improvements (Freeman). One involves analyzing relevant market transactions in goods and services which may have substitute or complementary relationships with an environmental amenity. (The travel cost approach to measuring recreation benefits is a prime example, e.g., Knetsch.) Alternatively, the researcher may employ the "contingent valuation" approach using sample surveys that ask beneficiaries to identify their willingness to pay for specified levels of a nonmarketed good.

Each approach has both advantages and disadvantages for obtaining estimates of the demand for a public good such as instream flow. Most economists prefer to use market data, since such analyses are based on actual behavior rather than hypothetical situations. Many share Freeman's (chap. 5) reservations about the direct questioning approach, primarily because of the potential for strategic behavior by interviewees. Such behavior may bias results toward the respondents' preferred policies. However, the travel cost approach is too blunt for our purposes because instream flows vary unpredictably according to short-term climatic factors and withdrawal requirements. We therefore employed a direct questioning approach.

We adopted Bradford's theoretical base for the contingent valuation method of measuring public good demand. The object is to estimate a total willingness to pay (bid) function that reflects the recreationist's ranking between alternative income and instream flow quantities. Individual bid functions have the same economic meaning as indifference curves with a slope measuring the marginal substitution rate between income and instream flow levels. Maximum bid responses over all instream flow levels map out a total instream flow benefit function. Its first derivative is the marginal benefit function (also known as a compensated demand function).

Recreation activities may generate both collective and private benefits. For example, a fisherman who catches and keeps some fish receives private benefits which preclude others from deriving benefits from the same fish. Noncapture activities, such as viewing or catch-and-release fishing, generate collective benefits. To value instream flows which help produce recreation benefits, our model assumes that instream flow (unlike the actual catch, number of visits, congestion, fishing skill, equipment, and other inputs used to produce private benefits) enters the recreation production function as a collective input. For example, an increase in the stream flow enhances the fishing experience for all by in-

creasing the stream's carrying capacity at all sites. Similarly, all white-water recreationists can enjoy faster and higher rapids, and all shoreline users can enjoy the sights and sounds of a rapidly flowing stream. The specific model valuing instream flow for fishing activities is

$$(1)\quad WTP_j = g[S(F), C(F), V_j(F), Z(F), Y_j, E_j, T_j],$$

where WTP_j is a measure of willingness to pay to obtain an additional cubic foot per second in the flow for the jth fisherman; Y_j, a measure of income; T_j, an array of taste and socioeconomic characteristics; E_j, years of fishing experience; $S(F)$, specific recreation site; $Z(F)$, a measure of congestion on the stream; $C(F)$, a measure of the potential catch rate; $V_j(F)$, the number of days the individual visited the river to fish during the season; and F, instream flow, measured in cubic feet per second (cfs).

Because recreationists cannot make instream flow quantity adjustments themselves, WTP_j is a Hicksian compensating surplus value. This research used a "willingness to pay" measure rather than a "willingness to accept compensation," because water institutions allocate water rights to withdrawal users. Any instream flow strategy represents a potential Pareto improvement given the recreationist's initial water right status (Brookshire, Randall, Stoll). Following Hammack and Brown, we assume that the utility from other activities in which the individual might participate during a recreation day are independent of utility of the instream recreation experience.

The instream flow variable, F, represents the water planner's controllable policy instrument. Property rights in water under the western appropriation doctrine are usually specified in terms of the priority status of the right and the flow (in cubic feet per second) the owner can divert (Ditwiler). To increase or decrease stream flow for recreation, the public agency would need to acquire direct flow rights, release upstream storage, or change the priority sequence (i.e., the first right would be a flow requirement).

The willingness to pay for additional flow will vary according to the aesthetic qualities of the river, $S(F)$, the potential catch rate, $C(F)$, the number of visits, $V(F)$, and congestion, $Z(F)$. We used color photographs of eight different instream flow rates (in cfs) at four different sites to capture the aesthetic value of instream flow, $S(F)$. The photographs, taken at various times during 1977, showed the stream at approximately 50, 100, 200, 350, 400, 600, and 850, and 1150 cfs. (Due to the serious drought of that year, our highest flow photographs represented only about one-fourth of normal maximum flows.)

In addition, we provided each fishing respondent with technical information on the potential trout catch rate per hour, $C(F)$, river depth, and velocity at each flow rate and site combination. This information was based on a physical survey of each site to determine the cross-section profile of the stream bed. A hydrologic model (Bovee and Milhous) predicted the stream's depth and velocity at each cfs rate for each site, and a fish habitat model (Bovee and Cochnauer) was adapted to forecast potential catch rates at each site under each flow condition. The biological model indicated that the optimal rainbow and brown trout stream conditions (average over four sites) occurred when the instream flow approximated 500 cfs. When stream flow exceeds 500 cfs, the resulting velocity, depth, and turbidity reduce the Poudre River's fishing value.

The model uses potential catch rate instead of the actual catch rate (the latter being a function of the fishing population) and number of visitors. Because a flow change toward the optimum increases the number of fish the stream can support and encourages more fishermen, the actual catch rate for individuals may increase, decrease, or remain constant depending on how many others use the stream. However, the potential catch rate depends only on the stream's physical characteristics and flow.

Demographic characteristics are measured using the participant's sex, age, education, occupation, employer, and residence. The interview date served as a partial indicator of congestion. The assumption is that if congestion significantly affects the willingness to pay, those that participate on weekdays will bid higher than those who participate on weekends.

Questionnaire Design and Interview Procedures

Randall, Ives, and Eastman, and Brookshire, Ives, and Schultze were among the first to employ contingent valuation techniques using photographs of alternative environmental situations. Following the contingent valuation approach, the interviewer, using color photo-

graphs and physical stream characteristics, asked each respondent to reveal his/her willingness to pay for instream flow in terms of (*a*) a percentage addition to the present county sales tax on consumption expenditures and (*b*) an increase in a hypothetical entrance fee. (We interviewed the head-of-household participating in noncontact activities. In a test survey trial, individuals objected to being separated from their group.)

After showing the respondent the photograph representing the lowest instream flow quantity, and asking the respondent to estimate the average annual use, the interviewer asked how much he or she would be willing to pay for the experience represented by the next highest instream flow photograph. For example, the recreationist was asked to respond "yes" or "no" to the following question:

> If the entrance fee cost $__ per day, would you pay the fee so the members of your household could travel up the Poudre River Canyon to (*activity*) for __ day(s) of annual use, if that amount resulted in an increase in water flow from those in Picture A to Picture B?

The interviewer started the bids at $1 for the entrance fee game and at an addition of 0.1% to the sales tax rate for the sales tax game. If the respondent answered with a "yes," the interviewer raised the bid by $0.25 or 0.1% increments until the respondent answered "no." The dollar amount or tax rate at the last "yes" response was taken to be the household's maximum willingness to pay for specific instream flow improvement. The interviewer then repeated the questions assuming the respondent's average annual use was increased and then decreased by 50%. The process was then repeated for the other sites.

Because few individuals could visualize the expenditure implications of a specific percentage increase in sales tax, the interviewer first presented a table showing the annual dollar equivalent of the percent change in sales tax by family size and income. For example, a 0.1% addition to the sales tax rate for a family of four earning $20,000 represented a bid of $1.50.

The survey obtained 134 personal interviews of recreationists using the Poudre River during the summer of 1978. The sample included 49 fishermen, 45 shoreline recreationists (those camping, hiking, viewing, etc.), and 40 white-water enthusiasts (kayakers, rafters, and tubers). A benefit function was estimated for each activity. (See Daubert for further details, including the questionnaire and the photographs.)

To assure a representative and random sample of recreationists, interviews were conducted on random days during each month at various sites in the canyon. Although the survey took about an hour to complete, the acceptance rate exceeded 80%. Fishermen and shoreline recreationists were the most receptive, with only 7% and 19%, respectively, refusing the interview. However, kayakers and rafters often objected to the interruption, with 38% refusing.

A few recreationists responded with very low or zero bids. These recreationists were further questioned to establish if they were actually unwilling to pay for instream flow or if they were in fact protesting either payment method. Protest responses were not included in the final analysis. Respondents were somewhat more likely to protest the sales tax game than the entrance fee game. Possibly those with low utility for added stream flow realized that they would be helping to pay for others' enjoyment. Shoreline participants had the highest rate of protest against either game. Unlike fishing and white-water activities, higher instream flows are not crucial to enjoy shoreline recreation. This recreation group has less motivation to pay.

Results and Discussion

A priori reasoning suggests that the total bid curve will likely be nonlinear in relation to stream flow, and that it might be shifted by socioeconomic characteristics of the respondents. We used stepwise least squares regression to estimate parameters of the individual stream flow value equations for combinations of the variables shown in table 1. Household responses for shoreline activities were expressed in individual terms by dividing each response by the number of reported household members. After preliminary analysis, the final model was based on individual t-statistics, the sign on the estimated coefficients, and the stability of the coefficients on the flow quantity variable. In general, the coefficient on *Flow* and $[Flow]^2$ was insensitive to changes in model specification. Regression results are shown in table 2.

The fishing and shoreline regression equations, in the absence of congestion, showed total willingness to pay increasing at an in-

Table 1. Variables in Regression Models

Dependent Variable	
WTP:	Total willingness to pay (bid) per recreation day, activity i; respondent j; instream flow rate; for each payment alternative
Independent Variables	
Numerical variables	
Flow:	River stage in cubic feet per second (cfs)
Activity days:	Total number of annual recreation days in activity i by respondent j in Poudre Canyon
Substitute days:	Number of water-based activity days on alternative rivers
Experience:	Years of participation in activity i by respondent
Income:	Annual household income of respondent
Age:	Age of respondent
Education:	Years of schooling of respondent
Zero-one dummy variables	
Site:	Site of photograph (four sites)
Sex:	$M = 1$, $F = 0$
Occupation:	(*a*) Professional; (*b*) business owner; (*c*) skilled worker; (*d*) sales; (*e*) clerical; (*f*) unskilled; (*g*) housewife; (*h*) retired; (*k*) student
Employer:	(*a*) Manufacturer; (*b*) construction; (*c*) retail; (*d*) financial; (*e*) health; (*f*) education; (*g*) public sector; (*h*) agriculture; (*k*) unemployed
Previous residence:	Size of community of previous residence (*a*) large city; (*b*) medium city; (*c*) small city; (*d*) town; (*e*) rural and farm
Date of interview:	(*a*) Month; (*b*) weekday; (*c*) weekend

creasing rate for flows between 0 and 200 cfs and increasing at a decreasing rate up to approximately 500 cfs (700 cfs for shoreline willingness to pay), then finally decreasing. White-water recreation models, however, did not follow that pattern. Instead, total willingness to pay increased for all instream flow quantities photographed. This may be because the 1977 drought caused maximum flows in our photographs to fall short of levels at which diminishing marginal utility would be observed.

The final quadratic regression equation for fishing and shoreline activities and the linear white-water equation fit the data reasonably well for a cross-section survey. Fishing entrance fee and sales tax equations explain 41% and 43%, respectively, of the variation in household willingness to pay. Shoreline entrance fee and sales tax equations explain 52% and 50% of the bid variation. The R^2's of white-water entrance fee and sales tax equations are .52 and .66, respectively.

Instream flow quantities are the principal determinant of fishing and white-water willingness-to-pay responses. According to t-ratio tests, *Flow* and $[Flow]^2$ are highly significant. Inspection of successive solutions of the stepwise regression indicate that *Flow* and $[Flow]^2$ explain, respectively, 20% and 21% of household fishing bid variations. Flow, alone, is highly significant in the white-water model (t-ratios equal to 15.05 and 21.68 in the entrance fee and sales tax models) explaining 38% and 53% of the bid variation. Even though *Flow* and $[Flow]^2$ are significant (t-ratios equal 2.29 and 2.18) in the shoreline user models, these variables explained only 3% and 6% of the bid variation. Since instream flows provide primarily visual aspects of noncontact recreation experiences, those users seem relatively indifferent between alternative instream flow levels except when the Poudre River is very low or extremely high. Other factors (tastes, visitation, for example) are more important in determining willingness to pay for this type of recreation.

It is possible that the variance in willingness to pay at low and high flows differs from the variance at medium instream flows. However, neither the Bartlett nor the Goldfield-Quandt tests rejected the null hypothesis that the different groupings of willingness to pay had the same bid variances (Pindyck and Rubenfeld).

Total and Marginal Value Functions

To analyze individual valuation of instream flows, we expressed the estimated equations solely as a function of flows. The equations are restated with all variables (except *Flow* and $[Flow]^2$) evaluated at their mean values. The first derivative of the total value function with respect to flow rate yields the marginal value function. The resulting equations are given below. (*TV* and *MV* are total value and marginal value, respectively.) The total value expres-

Table 2. Regression Estimates of Willingness to Pay for Instream Flow, Poudre River, Colorado 1978

		Fishing		Shoreline		Whitewater	
Variable[a]	Unit	Entrance Fee Game	Sales Tax Game	Entrance Fee Game	Sales Tax Game	Entrance Fee Game	Sales Tax Game
Constant term		2.14	3.11	1.40	1.25	0.50	−0.90
		(1.55)[b]	(1.31)	(0.34)	(4.94)	(1.19)	(1.71)
Flow	cfs	0.129	0.176	0.029	0.036	0.019	0.029
		(3.55)	(4.65)	(2.29)	(2.61)	(15.05)	(21.68)
$(Flow)^2$	$(cfs)^2$	−0.138 E-3	−0.156 E-3	−0.213 E-4	−0.27 E-4	[c]	
		(5.28)	(5.78)	(2.18)	(2.56)		
Activity days	Day	−0.130	−0.181	0.20	0.24	0.18	1.13
		(5.97)	(6.79)	(5.30)	(5.06)	(6.35)	(7.55)
$(Activity\ days)^2$	Day^2	0.21 E-2	0.003	−0.0097	−0.005	−0.004	−0.003
			(3.60)	(2.48)	(3.94)	(3.51)	(2.92)
Experience	Years	0.430	0.283	−0.10	−0.19	0.042	0.059
		(4.85)	(2.15)	(6.02)	(5.23)	(5.69)	(6.08)
Income	Dollars		0.0013	0.0086	−0.008		
			(2.90)	(2.18)	(2.09)		
Age	Years			−0.066		−0.55	−0.062
				(6.31)		(2.34)	(2.91)
Education	Years	−0.710		−0.28			
		(4.91)		(6.34)			
Dummies							
Sex	0-1			0.32			
				(3.47)			
Site 2	0-1	−0.36	−0.67				
		(2.50)	(3.37)				
4	0-1					−0.34	−0.17
						(2.11)	(6.07)
Occupation (*c*)	0-1		0.48				
			(2.56)				
(*d*)	0-1			0.76			
				(5.34)			
(*e*)	0-1	−1.28	−0.35		1.09		
		(4.30)	(3.19)		(5.25)		
(*f*)	0-1					0.61	
						(2.27)	
(*g*)	0-1	−1.37	−0.97	1.91	2.51		
		(4.40)	(2.35)	(6.94)	(8.41)		
(*h*)	0-1			1.51			
				(6.32)			
Employment (*a*)	0-1	0.810	0.35	−0.55	−1.39		
		(4.76)	(3.19)	(4.80)	(4.45)		
(*b*)	0-1					1.59	
						(4.21)	
(*d*)	0-1	0.854					
		(4.08)					
(*e*)	0-1	1.140		0.59	0.44		−0.82
		(2.73)		(4.92)	(4.09)		(3.07)
(*f*)	0-1		0.88	0.20	0.33	−0.87	
			(4.53)	(2.83)	(2.23)	(2.76)	
(*g*)	0-1				−1.07		
					(4.43)		
Previous residence (*a*)	0-1		−0.83				
			(5.14)				
(*b*)	0-1		1.65	0.73	0.56	0.49	1.17
			(6.51)	(5.26)	(2.63)	(2.59)	(4.36)
(*c*)	0-1				0.91		
					(6.00)		
(*d*)	0-1	0.564		1.01			
		(4.60)		(3.88)			
R^2		0.41	0.43	0.52	0.50	0.52	0.66
F		26.98	29.01	24.68	54.21	52.11	76.29
N		49	49	45	45	40	40

[a] Variables are omitted which did not enter the stepwise regression model for any case.
[b] Numbers in parentheses are students' *t*-ratios.
[c] Entries left blank represent variables which did not enter the stepwise regression model.

sion for white water is linear, so the marginal value is a constant for each game.

Fishing

(2a) Entrance Fee Game
$TV = 0.10 + 0.129[Flow] - 0.138E{-}3[Flow]^2$

(2b) $MV = 0.129 - 0.276E{-}3[Flow]$

(3a) Sales Tax Game
$TV = 0.052 - 0.176[Flow] - 0.156E{-}3[Flow]^2$

(3b) $MV = 0.176 - 0.312E{-}3[Flow]$

Shoreline

(4a) Entrance Fee Game
$TV = 0.080 - 0.029[Flow] - 0.213E{-}4[Flow]^2$

(4b) $MV = 0.029 - 0.426E{-}4[Flow]$

(5a) Sales Tax Game
$TV = 0.110 - 0.036[Flow] - 0.27E{-}4[Flow]^2$

(5b) $MV = 0.036 - 0.54E{-}4[Flow]$

White Water

(6a) Entrance Fee Game
$TV = -0.075 + 0.019[Flow]$

(6b) $MV = 0.019$

(7a) Sales Tax Game
$TV = -0.091 + 0.029[Flow]$

(7b) $MV = 0.029$

Possible Bias

Because bidding games may lead to strategic or biased responses, Bohm recommends that the research design include at least two different willingness-to-pay situations. One game should encourage understatement, the other overstatement. The interval between the two will be small or large depending on how strongly respondents react to the specific biases in each question design.

The estimated bid functions for the three recreation activities were statistically different for each repayment obligation; sales tax marginal benefits always exceeded entrance fee values. Sales tax responses exceeded entry fee bids by approximately $10 per day for fishing activities, approximately $5 for white-water activities. The entrance fee game, confronting each recreationist with his stated valuation, might encourage understatement. On the other hand, respondents might overstate their true preferences in a sales tax game, since payments are not a function of use and respondents know that all taxpayers would help pay for their recreation experience.

Derivation of Total and Marginal Values

We illustrate the derivation of total and marginal values by reference to the fishing entrance fee results. Table 3 presents total and marginal values derived from the entrance fee equations.

Table 3. Estimated Total and Marginal Values of Instream Flows for Fishing Activities, Poudre River, Colorado, 1978 (Entrance Fee Game)

	Total Value (WTP/day)		Marginal Value (WTP/cfs/day)	
Flow	Individual	Aggregate[a]	Individual	Aggregate[a]
(cfs)	($/day)	($/day)	($/cfs/day)	($/cfs/day)
100	11.67	2,661	0.102	23.23
200	20.48	4,669	0.074	16.94
300	26.53	6,049	0.047	10.65
400	29.82	6,799	0.019	4.35
500	30.35	6,920	−0.009	−1.94
600	28.10	6,411	−0.036	−8.23
700	23.15	5,274	−0.064	−14.52
800	15.40	3,507	−0.091	−20.82
900	4.85	1,110	−0.119	−27.11

[a] Based on an average daily visit in 1978 of 228 fishermen. Source: Arapaho and Roosevelt National Forest Headquarters, Fort Collins, Colorado.

Recreation Day Values

Column 2 of table 3 shows the value per recreation day (for a representative individual fisherman) assuming no congestion effects. For fishing, the maximum value per day is about $30, at a flow of nearly 500 cfs, while lower or higher flows are significantly less valuable. (The recreational day value in shoreline activities peaks at 700 cfs, with a smaller unit day value of about $10, while the white-water value schedule increases throughout the range of the observations.)

These values would change if congestion significantly reduces the individual's bid. While this study did not directly measure congestion effects, the mean bid by participants on weekdays was not significantly different from the mean bid by participants on weekends, even though the number of users is greatly increased. Walsh et al., however, reported significant congestion effects in another context. Thus, our values could overstate the recreationist's willingness to pay.

The estimates of individual willingness to pay per day for water-based recreation are comparable with other estimates. Gordon, Chapman, and Bjornn reported travel cost results for fishing for salmonids on Idaho streams as ranging from $23 to $34 per day. Charbonneau and Hay estimated a daily value of $25 for trout and landlocked salmon from the U.S. National Sample of Anglers via a bidding game approach. (Both of these estimates are adjusted to reflect 1978 price levels.)

Aggregate Values

Column 3 of table 3 presents the aggregate value per day resulting from the summation of individual bids according to the average participation rates as related to flow. Figure 1a illustrates these results. The aggregate values would be expected to change as both instream flow and user days changed. For each flow rate, the respondent was asked how his/her bid would change if the river were visited more or less per year. The results indicated that the bids by noncontact and white-water participants diminished as visitation increased (holding flow constant). Fishermen, however, were willing to pay more at the margin for increased visitation when instream flow approximated the optimal, and less at the margin when visitation increased at low and high flows.

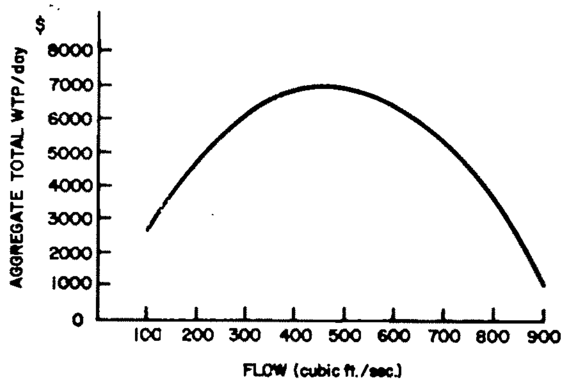

Figure 1a. Estimated aggregate total willingness to pay for flow by fishermen, Poudre River, Colorado, 1978

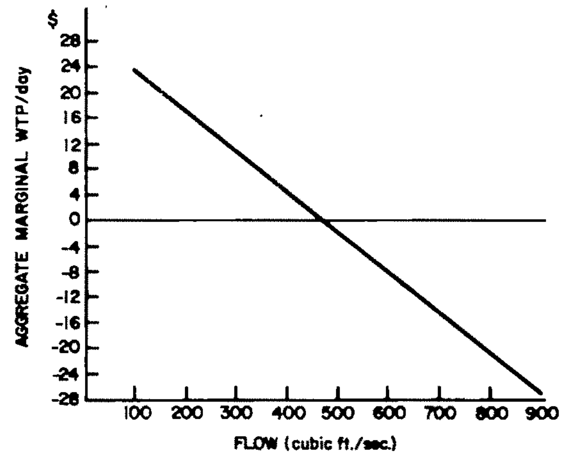

Figure 1b. Estimated aggregate marginal willingness to pay for flow by fishermen, Poudre River, Colorado, 1978

Marginal Values of Instream Flows

The primary research objective was to develop estimates of marginal value (demand) functions for instream flows. These are provided by the first derivatives of the bid functions with respect to flow. Table 3 (columns 4 and 5) contains a set of illustrative results regarding individual and aggregate marginal values for the fishing entrance fee game.

The fishing marginal value function, generally consistent with conventional economic theory, exhibits a negative slope. For example, if the Poudre River's flow is low (100 cfs), the fishing marginal instream value is relatively large, but it falls to zero as instream flows approach 500 cfs. The aggregate marginal bid (demand) function for fishing (entrance fee game) is illustrated in figure 1b. This corresponds to the total bid function in figure 1a.

Policy Comparisons

At certain locations and times, water flows in the Cache la Poudre River compete with or complement diversions and storage for crop irrigation. To compare marginal values in alternative uses, we converted the flow-based estimates into a volume measure, dollars per acre foot. Table 4 summarizes monthly estimates of marginal value of water for fishing. It also provides monthly estimates of the short-run marginal value of water for irrigation. These particular policy implications employ aggregate marginal willingness to pay only for fishing, since that activity dominates recreation values in the Poudre River area. Also, only the entrance fee results are presented.

During May, June, and July when the average monthly instream flow exceeds the optimum for fishing, recreation and crop irrigation are complementary outputs. Increased storage or diversion for irrigation upstream from fishing sites will increase both fishing and crop production. Water managers satisfying economic efficiency criteria should allocate more water to withdrawal until fishing and irrigation become competitive.

In September, present water allocation policies may not be allocating instream flows efficiently. The average September instream flow at the canyon mouth, 105 cfs, results in an aggregate marginal fishing return equal to \$10.54 per acre foot and a marginal crop return equal to \$7.22 per acre foot. To fulfill efficiency conditions, the instream flow should approximate 200 cfs where the marginal instream flow aggregate return of \$7.68 per acre foot approximates the marginal crop irrigation return of \$7.22 per acre foot. (The above assumes that this amount of water would have an insignificant impact on the marginal value of water in irrigation in the river basin as a whole.)

Our results also suggest that water managers could switch some reservoir filling from fall to spring and, thereby, increase social benefits. Many irrigation companies begin filling high mountain storage reservoirs in September and downstream reservoirs in the spring. In fact, they store over 1,000 acre feet (af) in high mountain reservoirs in September and 2,000 af in October. This water could have augmented the river's normal flow by 33 af/day and 66 af/day. Additional flow for fishing experiences is worth \$10/af in September and \$7/af in October.

Reallocating water storage from high mountain reservoirs to reservoirs near farming areas could substantially increase total benefits from water use in the fall. For example, if water managers let the 1,000 af stored in September flow downstream past major recreation areas

Table 4. Aggregate Marginal Value of Instream Flow for Fishing and Crop Irrigation by Month, Poudre River, Colorado, 1978

Flow	May	June	July	August	September	October	Average over Season
(cfs)	($/af)						
	Aggregate Marginal Value of Flow for Fishing/Acre Foot (Entrance Fee Game)						
100	6.79	3.50	20.41	20.41	10.54	6.79	11.71
200	4.92	2.54	14.81	14.81	7.65	4.92	8.54
300	3.13	1.61	9.40	9.40	4.86	3.13	5.37
400	1.26	0.65	3.80	3.80	1.96	1.26	2.19
500	−0.60	−0.31	−1.80	−1.80	−0.93	−0.60	−0.98
600	−2.40	−1.23	−7.20	−7.20	−3.72	−2.40	−4.15
700	−4.26	−2.19	−12.81	−12.81	−6.61	−4.26	−7.32
No. of fishermen per day[a]	132	68	397	397	205	132	228
Average monthly flow (cfs)[b]	775	1,542	703	218	105	123	578
	Marginal Value of Irrigation Water ($/acre foot)[c]						
Normal year flow	1.75	3.30	9.00	15.00	7.22		7.25
Dry year flow	1.75	3.30	45.10	40.00	12.90		22.41

Note: Factor for converting cubic feet per second (cfs) to acre feet per day: 1.964 cfs for 24 hours equals 1 acre foot.
[a] Arapaho and Roosevelt National Forests, Fort Collins, Colorado.
[b] Average between 1961 and 1975.
[c] Derived from Daubert, Young, and Morel-Seytoux.

before storing, total fishing benefits would increase by $380 per day or approximately $10,000 for the month. In October, when total recreation benefits would increase by at least $11,000, this water policy change increases the river's fishing benefits without decreasing next year's crop output. Water supplies remain constant or even increase; only the storage timing changes.

Conclusion

Like other environmental amenities, instream flow for recreation has collective good attributes that inhibit conventional market allocation. The contingent valuation approach was adapted to impute instream flow shadow prices by a sample of recreationists on the Cache la Poudre River in northern Colorado. By directly estimating the recreationist's willingness to pay for instream flow quantity changes, it was possible to determine marginal values of water that are comparable and commensurate with the marginal value of water in withdrawal uses. The findings indicate that variations in instream flow strongly affect fishing and white-water recreation experiences. It is less significant for shoreline activities.

The demand (marginal benefit) functions, estimated by the contingent valuation technique, seem to be plausible and generally reliable in a statistical sense. The technique successfully discriminated among the flow values in the various activities. Flow is significant to fishing and kayaking. In the range of flows considered, diminishing marginal utility was observed for fishermen but not for white-water users. While flow also was a factor in shoreline uses, it was less significant and smaller than for the other recreation activities. These kinds of estimates could provide an improved basis for water allocation decisions by management authorities. These results are relatively site-specific and it is not necessarily appropriate for decisions at alternative sites. However, we think that the method is of sufficient usefulness to recommend it for further test and refinement at other locations.

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Determinants of Hunter Participation: Duck Hunting in the Mississippi Flyway

Jon R. Miller and Michael J. Hay

In this paper the authors study the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting in the Mississippi Flyway. Using socioeconomic data from the *1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation,* and waterfowl habitat data from the 1970 Flyway Habitat Management Unit Project, they estimate probability and intensity of participation equations for duck hunting. The analysis differs from previous population-specific recreation studies in (*a*) the narrowly defined activity, (*b*) more precise definition of supply variables, (*c*) use of variables representing distance to hunting sites, and (*d*) the use of logit analysis to estimate participation probability equations.

Key words: hunting, logit analysis, recreation demand.

Increasing pressure for development of natural areas and continued growth in outdoor recreation emphasize the need for planning methodologies that improve decisions affecting recreation resources. In the case of wetlands, development is often incompatible with waterfowl hunting, an important recreational activity that requires natural habitat for a sustaining source of waterfowl and for hunting sites.

Acquisition of waterfowl habitat to prevent its alteration for agricultural purposes has been a high priority for years in the prairie pothole region of the Mississippi Flyway and is increasingly so in the Mississippi Delta bottomland area. Recently, however, there has been growing resistance to the acquisition program by those who believe agricultural development is a better use of wetlands than is their preservation as waterfowl habitat. Improved methods of estimating benefits of wetlands preservation will permit more quantitative analyses of the trade-offs involved.

Recreation, in the form of waterfowl sport hunting, is one of several important benefits provided by wetlands and the waterfowl populations they support. The focus of this paper is on the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting in the Mississippi Flyway. Equations such as those presented in this paper can be used to predict how the number of hunters (and how often they hunt) would be affected by continued loss of habitat and the resulting changes in hunter success. In addition, the change in days of participation may be converted to dollar magnitudes through multiplication by day values obtained from other sources.

Our analysis differs in some important ways from previous studies of determinants of recreation behavior (Kalter and Gosse; Cicchetti, Seneca, Davidson; Cicchetti 1972, 1973; Deyak and Smith). First, we examine the determinants of participation in a narrowly defined, wildlife-related, recreation activity, rather than a broad category such as general hunting or fishing. This permits more precise definitions of supply or availability variables (e.g., the use of waterfowl habitat and hunter success measures) and makes the analysis more useful for wildlife resource management. Second, we incorporate a measure of average distance traveled to hunt waterfowl as a proxy for access-related costs of hunting. Finally, in contrast to other population-specific recreation economics studies, we estimate probability of participation equations with logit analysis rather than the commonly used linear probability model.

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The opinions and conclusions presented here are the authors' and not necessarily those of the U.S. Fish and Wildlife Service.

In the next section, we discuss the estimating equations. The third section is a discussion of data sources and variables. In the fourth section we discuss empirical results with emphasis on the supply variables measuring the availability of waterfowl habitat and average hunter success. We then illustrate how the methodology of this paper could be used in policy analysis. In a concluding section we summarize and make suggestions for improving recreation participation studies.

The Estimating Equations

Any broadly based sample of individuals will include a large number who do not participate in duck hunting. Attempting to identify determinants of participation from such a sample by regressing days of participation on explanatory variables will result in a large concentration of values of the dependent variable at zero. This concentration of the dependent variable at a lower bound will result in underestimates of participation for those who participate. In such a case, the classical regression model is inappropriate (Goldberger, p. 252). To alleviate this problem we use a two-step estimating process: (*a*) estimation of probability of participation equations, and (*b*) estimation of the level or intensity of participation equations for those who participate. Estimation of the first step equation uses a logit estimation technique. Most previous recreation participation studies have used ordinary least squares (OLS) for estimation of linear probability equations in step one. Three major problems are associated with this approach: (*a*) the error terms are not normally distributed and violate the classical least squares assumption of homoskedasticity, resulting in inefficient estimators; (*b*) because the error terms are not normally distributed, *t*-tests of significance do not apply; and (*c*) predicted probabilities from the estimated equation could yield values outside the 0–1 probability interval (Goldberger, Nerlove and Press, Netter and Maynes, Zellner and Lee).

Alternative binary choice models avoid these problems. The two most popular alternatives are the probit and logit formulations.[1]

[1] Most applications of logit and probit are based on the works of Berkson and Finney. More recent applications are Heckman, Amemiya, and in this *Journal*, Hill and Kau. Particularly readable presentations of the technique may be found in Wonnacott and Wonnacott (pp. 131–4) and Pindyck and Rubinfeld (pp. 245–56).

The primary concept underlying these binary choice models is the threshold of response. In the context of this study, an individual either hunts waterfowl or does not. We assume an individual's participation decision is a function of socioeconomic characteristics and the availability of waterfowl habitat and populations. If the value of this function exceeds some threshold value for the individual, the individual will participate. For the *i*th individual, Y_i, is defined as follows:

$$(1) \qquad Y_i = \begin{cases} 1 \text{ if } I_i \geq I_i^* \\ 0 \text{ if } I_i < I_i^* \end{cases}$$

I_i^* is the individual's response threshold, and I_i is a linear function of the explanatory regressors, i.e., $I_i = \alpha + X_i'\beta$. The probit model assumes that I_i^* is a normally distributed random variable. With I_i^* distributed normally, the probability that $I_i > I_i^*$ is simply the value of the cumulative normal probability function evaluated at I_i. The cumulative normal function has an *S* shape with the probability values bounded by zero and one. Estimation is usually done with iterative maximum likelihood techniques.

Since the cumulative logistic probability function is basically similar in form to the cumulative normal function, it is often substituted for it because of its relative computational ease. In logit analysis, the probability that the individual will participate is

$$(2) \quad P_i = F(I_i) = \frac{1}{1 + e^{-I_i}} = \frac{1}{1 + e^{-(\alpha + X'_i\beta)}}.$$

The specification is more apparent if (2) is rearranged, i.e.,

$$(3) \qquad \log\left(\frac{P_i}{1 - P_i}\right) = \alpha + X'_i\beta.$$

Rather than the probability of the occurrence being a linear function of the explanatory variables, as in the standard linear probability model, the logit formulation assumes the log of the odds, or logit, is a linear function of the explanatory variables. The maximum likelihood coefficients are asymptotically consistent, efficient, and normally distributed, and the t-test is a valid test of significance. These desirable properties and the fact that the estimated probabilities are bounded by zero and one are the important advantages of logit estimation. While logit estimates are superior on theoretical and statistical grounds, compari-

sons of binary choice models show that when estimated probabilities lie within the extremes of the S-shaped curve, OLS or appropriately specified GLS estimates are similar to those of logit. Indeed, OLS-logit comparisons made in this study indicated little difference.

Our intensity-of-participation equation is based on the household production approach developed by Becker and recently adapted by Deyak and Smith for analysis of participation in outdoor recreation. While we believe the household production approach is theoretically appealing, reduced-form equations like the ones in this paper can also be derived from a more traditional supply-demand framework (e.g., see Cicchetti, Seneca, Davidson). In the household production framework, duck hunters are assumed to maximize utility functions expressed in terms of final service flows, one of which is measured as days of waterfowl hunting. The individual is both consumer and producer, combining purchased market goods, certain nonmarket goods, and time in the production of the final service flows. In the case of duck hunting, purchased goods include costs of travel, ammunition, and other equipment. Nonmarket goods include public duck-hunting sites and duck populations that are managed as common property resources by federal and state resource management agencies. As noted in the introduction, the influence of these latter variables is the prime concern in this paper. Waterfowl habitats and populations are viewed primarily as supply shifters, i.e., as the amount of habitat or the size of waterfowl populations increase, the cost to the hunter of a constant quality hunting day will fall and he will be induced to hunt more, other things remaining equal. Alternatively, availability could be viewed as a demand shifter, as the quality of hunting days would be expected to increase with availability. However, both influences are in the same direction, so we would expect the effect of availability of habitat and ducks on participation to be unambiguously positive.

The result, described in detail in Miller and Hay, and Deyak and Smith, is a reduced-form equation in which the number of days of duck hunting is a function of exogenous shifters of the individual's demand and supply (marginal cost) curves. Because it is a reduced form, the coefficients of this equation cannot be interpreted as either demand or supply structural parameters, but rather as measures of the joint effects of both supply and demand. The equations cannot be used to estimate economic values of hunting days or bagged ducks. Moreover, the lack of information in our survey data on the location of an individual's hunting activity, other than by state, precludes techniques such as the disaggregated travel cost approach (Brown and Nawas; Gum and Martin) to obtain value estimates. The methodology presented in this paper, however, is related to economic valuation. Recreation benefit evaluations typically provide estimates of participation and average or marginal values of a day of the activity under study. However, these evaluations are not designed to account for changes in participant numbers or level of activity over time as a result of changes in policy-related variables such as habitat and game populations. Participation studies, like the one presented here, help to fill this gap and permit broader use of such economic value estimates.

Data Sources and Definition of Variables

The primary source of data used in our empirical estimates is the *1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation* (U.S. Fish and Wildlife Service). The survey was conducted in two stages. The first stage consisted of a national telephone survey of a stratified sample of some 106,000 households nationwide. The telephone interview with the household head or other adult household member gathered demographic information about each member of the household and whether he or she had hunted or fished in the preceding year. The survey also asked if household members had engaged in wildlife watching or photography during the past year, and, if so, how often. Certain other data were also gathered. The second stage of the survey consisted of mailing questionnaires, with two follow-up mailings if needed, to a nationwide sample of hunters and fishermen identified in the telephone survey. In all, the survey resulted in usable information for more than 330,000 individuals in the telephone survey and more than 20,000 individual hunters and fishermen in the mail survey.

Estimating probability of participation in an activity based on survey data requires that the sample of individuals include some who participated in the activity of interest and some who did not. In our case, the telephone survey includes those who hunted in 1975 and those

who did not, but does not indicate what kind of hunting was engaged in (waterfowl, big game, etc.). More detailed information was gathered in the mail, follow-up survey. Hence, we divide our first-step probability estimation into two substeps; first, the probability that an individual engaged in hunting of any kind in 1975, and then, given that he hunted, the probability that he hunted ducks. Due to the large sample size generated in the telephone survey, the equation in the first substep is estimated with a randomly drawn subsample of hunters and nonhunters from the telephone phase of the survey. A probability-of-participation-in-duck-hunting equation is then estimated using all of the sample hunters in the Mississippi Flyway, some of whom hunted ducks while others did not. The second-step or level of participation equation is estimated for only those Mississippi Flyway hunters who had hunted ducks.

Table 1 shows the explanatory variables used in our equations. Most of the variables are standard measures and require no further explanation. The supply-related variables are based on state level data from sources other than the 1975 Survey. They are assigned to each individual in the sample based on his state of residence. For example, the variable *ACRES* is a per capita measure of public recreation areas and commercial forests and is included in the probability-of-hunting equations to represent relative availability of open space for hunting. Data on public recreation land area are derived from the results of the U.S. Bureau of Outdoor Recreation's unpublished *1972 Public Outdoor Recreation Areas and Facilities Inventory*. Commercial forest

Table 1. Definition of Variables

Variable Name	Definition	Units of Measurement
AGE	Age of respondent	years
AGESQ	Square of respondent's age	years
INC	Respondent's household's income	thousands of dollars
SEX	Sex of respondent	1 – if male 0 – otherwise
PREF	Intensity of preference for waterfowl hunting	1 – if waterfowl hunting is favorite activity 0 – otherwise
METRO	Metropolitan residence	1 – if residence is in metropolitan area 0 – otherwise
NONCON	Nonconsumptive fish and wildlife participation	1 – if respondent reported having observed or photographed wildlife in 1975 0 – otherwise
BAG	1974 average season bag of ducks per hunter in the respondent's state of residence	number bagged
MILES/DAY	Total season round trip automobile miles driven by the respondent for migratory bird hunting divided by total days of participation in the activity	miles per day
ACRE	Acres of public recreation land plus acres of commercial forest in respondent's state of residence	acres per capita
WHAB	Acres of waterfowl habitat in respondent's state of residence	millions of acres
WETHAB	Acres of wetlands and permanent water habitat in respondent's state of residence	millions of acres
UPHAB	Acres of upland waterfowl habitat in respondent's state of residence	millions of acres

acreage is from U.S. Department of Agriculture (USDA, p. 20). Per capita measures of this variable are used to capture the effect of general population and congestion pressures on the availability of hunting opportunities. General population, rather than hunter population, is used as the per unit measure, since other activities may affect the availability or suitability of hunting sites.

The measures of waterfowl habitat (*WHAB*, *WETHAB*, and *UPHAB*) are based on the Flyway Habitat Management Unit Project (U.S. Bureau of Sport Fisheries and Wildlife). That project produced estimates for 1965 of the acreage of three types of waterfowl habitat in each of the coterminous forty-eight states. The three habitat types are wetlands, permanent water, and upland habitat. More recent estimates are not available. The bag (hunter success) variable is derived from data compiled yearly by the U.S. Fish and Wildlife Service and reported by state and flyway (Carney, Sorenson, Schroeder).

Empirical Results

Three equations representative of the type of hunter participation analysis possible with the 1975 Survey data are presented here. More detailed empirical work may be found in Miller and Hay. Equation (4) is the estimated relationship between the log of the odds (logit) of hunting in general and hypothesized determinants of hunting. Equation (5) is a similar relationship for duck hunting. The coefficients represent the derivatives of the log of the odds with respect to the explanatory variables. The corresponding relationships to the probability of participation, P, are nonlinear. The partial derivatives of the nonlinear probability function evaluated at sample means appear below the asymptotic t-statistic shown in parentheses beneath the coefficients. The likelihood ratio index (*LRI*) is a logit analogue to the multiple correlation coefficient in least squares regression (Domencich and McFadden, p. 124), and is defined as

$$LRI = 1 - (\text{log likelihood at convergence/log likelihood at zero}).$$

$\bar{P}$ is the proportion of the sample that participated.

$$(4)\quad \ln\left(\frac{P}{1-P}\right) = \underset{\substack{(8.92)\\0.001}}{-5.764 + 0.156\,AGE} \;\; \underset{\substack{(-9.02)\\ —}}{-\,0.002\,AGESQ} \;\; \underset{\substack{(11.69)\\0.140}}{+\,2.463\,SEX} \;\; \underset{\substack{(1.33)\\0.015}}{+\,0.264\,HEAD} \;\; \underset{\substack{(-7.75)\\-0.015}}{-\,0.933\,METRO} \;\; \underset{\substack{(5.17)\\0.038}}{+\,0.666\,NONCON} \;\; \underset{\substack{(3.92)\\0.001}}{+\,0.021\,ACRES},$$

where $LRI = .263$, $\bar{P} = .137$, and $n = 2{,}752$. All coefficients in equation (4) are significant at the 1% level except the head of household dummy, significant at the 9% level. The quadratic relationship between *AGE* and the log of the odds indicates that increasing age affects hunting participation positively up to a point and then has an overall negative effect, other things being equal. Based on the coefficients of equation (4) the maximum probability of hunting occurs at age thirty-nine. This inverted U-shape relationship is in contrast to the findings of Cicchetti (1973), who reported that the probability of hunting was higher for young and for retired persons than for those in the middle age groups. Two other socioeconomic or demand-related variables have significant coefficients. Not surprisingly, men are more likely to be hunters than women. The negative *METRO* coefficient indicates that persons living in urban areas are less likely to hunt than individuals in nonmetropolitan areas, other things being equal. The coefficient of *ACRES* is significant with the expected positive sign. The positive coefficient of *NONCON*, the wildlife observation/photography dummy, suggests that consumptive (hunters) and nonconsumptive wildlife users (observers and photographers) may not comprise separate groups as is often suggested. Significant overlap exists. Hunters frequently take nonhunting, scouting trips to check potential hunting sites and game populations. In addition, a significant portion of the benefits of hunting is nonconsumptive in nature. Many people hunt primarily to experience nature, and to escape the stresses of the man-made environment. Hunters with such preferences likely take nonhunting trips for those types of benefits.

Equation (5) presents estimates of the determinants of participation in duck hunting, conditional on being a hunter.

$$
\begin{aligned}
(5)\ \ln\left(\frac{P}{1-P}\right) = {} & \underset{(8.06)}{2.673} - \underset{\substack{(-7.52)\\-0.005}}{0.026}\,AGE \\
& + \underset{\substack{(3.57)\\0.187}}{1.004}\,SEX + \underset{\substack{(4.71)\\0.004}}{0.019}\,INC \\
& - \underset{\substack{(-1.81)\\-0.034}}{0.180}\,METRO + \underset{\substack{(6.59)\\0.027}}{0.145}\,BAG \\
& + \underset{\substack{(6.28)\\0.058}}{0.313}\,WETHAB + \underset{\substack{(3.26)\\0.028}}{0.153}\,UPHAB,
\end{aligned}
$$

where $LRI = 0.064$, $\bar{P} = .27$, and $n = 2{,}786$.

These estimates focus the analysis more narrowly. The analysis is restricted to duck hunting in the Mississippi Flyway, and some notable changes occur in comparison to the more general equation (4). Again, all coefficients are significant at standard levels. The effect of *AGE* on the probability of participation is distinctly different for duck hunting than for hunting in general. Here the effect is negative throughout, with no U-shape relationship as was the case previously. The coefficient of income is positive and significant in these estimates, whereas it was not a significant determinant of the probability of participation in general hunting. This means that, among hunters, as income increases, the probability that an individual hunts ducks also increases, holding age and other factors constant. The coefficient of *SEX* is again positive, indicating that if women hunt, they are less likely than men to hunt ducks. The variables included as measures of duck hunting opportunities have the expected positive coefficients and consistently high t-ratios.

Average season bag per hunter in the respondent's state of residence (*BAG*) is a measure of hunter success in 1974. Success in the preceding year was thought to be the relevant measure for the decision whether to hunt or not in 1975. Average bag in the year of the activity could be used as an alternative success variable, as hunters may be induced to hunt if they perceive the current hunt to be going well. Including both variables in the same equation, however, resulted in a high degree of multicollinearity.

The measure of habitat availability is disaggregated into acres of wetlands including permanent water (*WETHAB*) and upland habitat (*UPHAB*). The coefficients of both variables are significant, with the partial derivative of *WETHAB* twice as large as that of *UPHAB*. This means that changes in availability of wetlands as hunting sites have more impact on duck-hunting participation rates than do changes in upland habitat, other things being equal.

The interpretation of these statistical estimates of the effects of success and habitat when entered as separate explanatory variables is also of policy interest. The positive coefficient of *WETHAB*, holding the bag measure constant, means that the rate of participation in duck hunting is expected to decline if wetland acreage decreases, even if hunter success is maintained at current levels by more intensive management of remaining habitats. The reduction in participation may result from increased access cost as wetlands decline, and from the negative impact of increased congestion on remaining sites.

Equation (6) is a logarithmic specification of a level-of-participation equation. The sample consists only of respondents who hunted ducks.

$$
\begin{aligned}
(6)\ \ln(DAYS) = {} & \underset{(0.39)}{0.202} + \underset{(2.70)}{0.110}\ln(INC) \\
& + \underset{(9.33)}{0.793}\,PREF + \underset{(3.00)}{0.252}\ln(BAG) + \\
& \underset{(1.87)}{0.079}\ln(WHAB) - \underset{(2.70)}{0.110}\ln(MILES/DAY),
\end{aligned}
$$

where $R^2 = .21$, $F = 34.64$, and $n = 627$. Some variables appear in this equation but not in equations (4) and (5). Preference intensity, *PREF*, has a strong positive impact on days of participation. Hunters who indicated that waterfowl hunting was their favorite hunting and fishing activity hunted ducks more than twice as many days in 1975 as did those who preferred another activity, other things being equal.[2]

The addition of a distance-travelled-to-hunt variable improves the overall fit of the step two equation. Miles per day is included as a proxy measure for the cost of access to hunt-

[2] In the multiplicative functional form, an intercept dummy variable such as *PREF* has the effect of increasing the intercept term, e^{β_0}. Thus, when $PREF = 1$, the intercept is $e^{\beta_0+\beta_1}$ where β_1, is the coefficient of *PREF*, and Y is e^{β_1} times larger than when $PREF = 0$.

ing sites. The most notable effect of the distance-travelled variable is that when *MILES/DAY* is included in the equation, *METRO* is no longer statistically significant. This suggests that the significance of *METRO* in the probability equations reflects the influence of access costs rather than urban-rural taste differences. Note that income has a positive effect on level of duck hunting, as it does in the probability equation. *WHAB*, measuring habitat availability, combines *UPHAB* and *WETHAB* which were not significant in equation (6) when entered separately.

Participation equations typically are used to test hypotheses about determinants of participation and to forecast numbers of participants and days of an activity. Hypothesis testing in terms of the effect of age, income, and other factors was discussed above. Forecasting, and the use of the estimates for policy purposes, can be illustrated by considering the effects on duck hunting of a 10% loss of waterfowl habitat in each state in the Mississippi Flyway, an average of 204,900 acres per state.

The reduction in habitat has the effect of reducing the number of duck hunters, as well as the number of days hunted by those who continue. Based on approximately 6.5 million hunters of all kinds in the flyway in 1975 and using partial derivatives from equation (5), a 10% habitat loss would reduce the probability that a hunter hunts ducks by .0087, resulting in 56,550 fewer duck hunters. If we assume those hunters would have hunted the sample average of 8.5 days per hunter, this implies a reduction of 480,675 hunter days. The days lost because those who still hunt ducks would hunt less often, estimated at .07 fewer days per hunter from equation (6), gives a further reduction of 118,892 days. Using $29 as the estimated consumer surplus value of a day of waterfowl hunting (Charbonneau and Hay), the total reduction of 599,567 days amounts to an annual loss of $17 million. Discounted at 7-3/8%, the annual loss has a present value of $235 million, representing an average value for duck hunting of $82 per acre of habitat. If, as one would expect, the loss of habitat leads to a lower average bag per hunter, there would be further reductions that could be taken into account by means of the bag variables in the probability and level of participation equations if the relationship between acres of habitat and hunter bag could be quantified.

Summary and Conclusions

Our main purpose was to improve the analysis of the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting. We presented examples of probability and intensity of participation equations estimated with data from the *1975 National Survey of Hunting, Fishing, and Wildlife Associated Recreation.*

Several variables of policy interest were statistically significant in determining hunter participation, e.g., waterfowl habitat and average bag levels. Equations estimated in this paper can be used to assess the effects on hunter participation of policy-related changes in waterfowl habitat and hunter success. Probability-of-participation equations were used to predict the change in the number of hunters, and days of participation equations to predict the change in the level of hunter activity. The estimates indicate that the reduction in duck hunting that would result from a 10% loss of waterfowl habitat in the Mississippi flyway has a discounted present value of $108 million. Estimation of the indirect relationship between habitat, game populations, and hunter success would require additional information.

Data limitations require that our empirical results be used cautiously. Our inability to determine from the survey data the extent of multiday trips is important, as is the lack of precise information on the location of the activity. Studies of waterfowl hunting and other fish and wildlife-associated recreation would benefit from improved and more extensive data on wildlife populations and their habitats. These data should be organized in geographical units (e.g., states, counties, game management units) which lend themselves to policy studies.

Our analysis has shown that differences in habitat availability and hunter success influence both the probability and intensity of waterfowl hunting. Our methods for assessing these impacts have considerable promise. Improved data and additional studies like this one can build confidence in the estimation techniques and, therefore, encourage a broader use of empirical results in planning and analysis.

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Evaluating Returns to Agricultural Research: A Review

George W. Norton and Jeffrey S. Davis

This paper reviews and compares the most common approaches used to evaluate public agricultural research investment. *Ex post* studies fall into two major groups: (*a*) consumer and producer surplus analyses, estimating average rates of return to research, and (*b*) production function analyses, estimating marginal rates of return to research. *Ex ante* studies fall into four groups: (*a*) those using scoring models to rank research activities, (*b*) those employing benefit-cost analysis to establish rates of return to research, (*c*) those using simulation models, and (*d*) those using mathematical programming to select an optimal mix of research activities.

Key words: literature review, public investment, research evaluation.

As public investment in agricultural research has expanded, attention has focused on its productivity and the efficiency with which funds are allocated. Decision makers desire information on research payoffs in order to assess alternative uses for public funds. In addition, the public itself is increasingly concerned about the productivity of its tax dollars.

This paper reviews the major research techniques that have been developed to evaluate returns to agricultural research. It extends previous reviews of Peterson (1971), Shumway (1973, 1977), Easter and Norton, Peterson and Hayami, Sim and Gardner, Schuh and Tollini, and Scobie (1979). We follow the Schuh and Tollini procedure of categorizing returns to research studies into *ex ante* and *ex post* evaluations. Major studies which illustrate each technique are discussed and compared to show (*a*) differences in assumptions made in studies using similar methods, (*b*) techniques appropriate to answer different questions, and (*c*) incomplete areas where methodology needs development or improvement.

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Ex Post Evaluations

Ex post evaluations fall into two major groups: (*a*) those using consumer and producer surplus directly and estimating an average rate of return to research, and (*b*) those estimating a marginal rate of return to research by treating research as a production function variable. In addition, there are two major studies outside these two classes: one estimates the impact of technology on national income and the other measures the nutritional impact of agricultural research.

Consumer and Producer Surplus Approach (The Index Number Approach)

Schultz (pp. 117–22) attempted the first major quantitative evaluation of agricultural research investments by calculating the value of inputs saved through more efficient production techniques compared to the cost of research and development. He estimated that output per unit of input was at least 32% higher in 1950 than in 1910. To have produced 1950 output with 1910 techniques would have required \$39.6 billion worth of inputs rather than the \$30 billion actually used (using 1910–14 price weights). He also derived an upper limit using 1946–48 price weights. In effect, he calculated the increase in consumer surplus resulting from the savings in inputs under the special conditions reflected in figure 1. The area under the completely elastic sup-

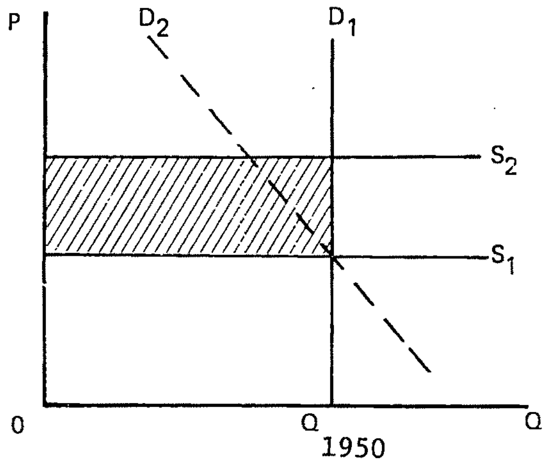

Figure 1. Value of inputs saved

ply curve S_1 to the left of the complete inelastic curve D_1 represents the total cost of producing 1950 output with 1950 techniques. The area between S_1 and S_2 to the left of D_1, represents additional resources required to produce that output with 1910 techniques.

Schultz pointed out that a downward bias in research returns resulted from this estimation because all public research and extension expenditures were not aimed at producing and distributing new techniques. An upward bias resulted from neglect of private research and from the implied perfectly inelastic demand curve. This bias is likely to be small for agricultural products because of their low demand elasticity.

Since Schultz's work there have been many consumer-producer surplus (CS) research evaluation studies, most at the commodity level. General discussions of consumer surplus concepts can be found in Currie, Murphy, and Schmitz; Hertford and Schmitz; and Willig. Griliches (1958) calculated the loss in net social surplus if hybrid corn were to disappear. His analysis assumed that adoption of hybrid corn shifted the supply curve for corn downward or to the right. He estimated returns for the polar cases of perfectly elastic (fig. 2) and perfectly inelastic (fig. 3) supply curves, implicitly assuming a unitary demand elasticity.

In figure 2 the change in consumer surplus equals $E + F$, which equals $KP_1Q_1(1 - \frac{1}{2}Kn)$ where $K = \frac{\Delta P}{P_1}$ and n is the absolute value of the demand elasticity. In figure 3, the change in net economic surplus equals $A + B - A + C$

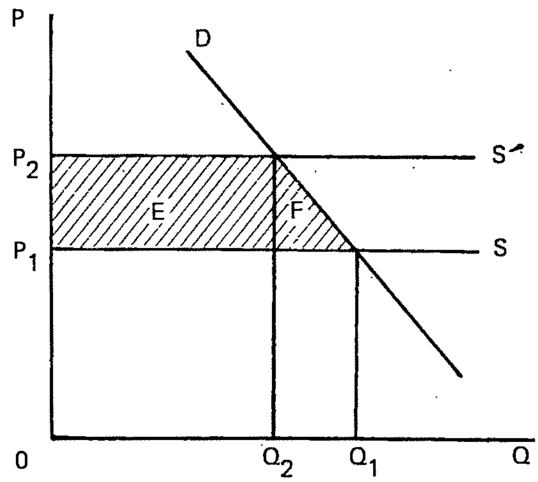

Figure 2. Hybrid corn, perfectly elastic supply

which equals $KP_1Q_1\left(1 + \frac{1}{2}\frac{k}{n}\right)$ where $K = \frac{\Delta Q}{Q_1}$.

Peterson (1967) developed a formula for estimating net social surplus changes for poultry research which eliminated Griliches's supply and demand elasticity restrictions. As illustrated in figure 4, when price and quantity move from P_1 to P_2 and from Q_1 to Q_2, respectively, Peterson's change in net economic surplus $= A + B + C + E + G + (-A - B + H + I + J) = C + E + G + H + I + J$. He reasoned that this area is approximately equal to $I + J + K + L + E + G - D$ and provided the following expression to approximate it:

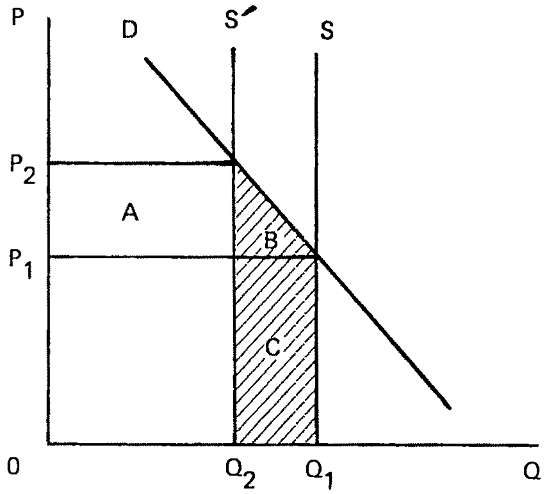

Figure 3. Hybrid corn, perfectly inelastic supply

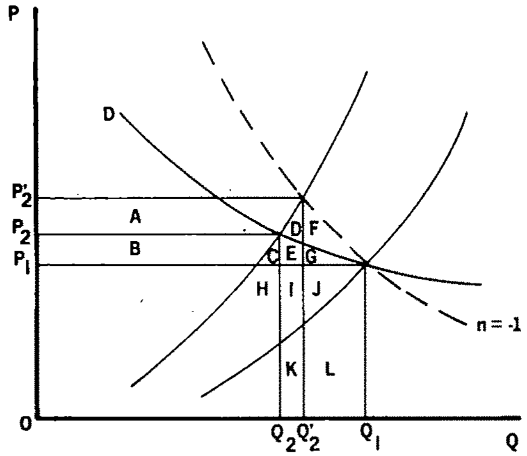

Figure 4. Poultry supply shift resulting from the use of new inputs

$$(1) \quad KQ_1P_1 + \tfrac{1}{2}K^2P_1Q_1/n - \tfrac{1}{2}Q_2K^2P_1\left(\frac{P_1}{P_2}\right)\left(\frac{en}{n+e}\right)\left(\frac{n-1}{n}\right)^2,$$

where n is the absolute value of the demand elasticity, e the supply elasticity, and K the percentage shift in the supply curve $\frac{Q_1 - Q'_2}{Q_1}$. He compared this with costs of research and extension and calculated an internal rate of return. The above expression reduces to

(2) $KQ_1P_1(1 + K/2n)$ if $n = 1$ or $e = 0$.

Hertford and Schmitz provided the following formulas for estimating changes in net social surplus if the demand and supply curves represented in figure 4 are linear and the supply shift is parallel:

(3) change in total net social surplus

$$= KP_1Q_1\left(1 + \tfrac{1}{2}\frac{K}{n+e}\right),$$

(4) change in consumer surplus

$$= \frac{KP_1Q_1}{n+e}\left(1 - \tfrac{1}{2}\frac{Kn}{n+e}\right),$$

(5) change in producer surplus

$$= KP_1Q_1\left\{1 - \frac{1}{n+e}\left[1 - \tfrac{1}{2}K\left(\frac{2n+e}{n+e}\right)\right]\right\},$$

where K is defined as the horizontal distance between S' and S.

Schmitz and Seckler extended the model to account for resources (labor) released with the introduction of new technology (the mechanical tomato harvester). They estimated net benefits as "value of inputs saved" minus "value of labor lost." First they assumed displaced labor would receive no compensation; then they assumed alternative compensation levels.

Ayer and Schuh (1972) altered the model to make Brazilian cotton supply dependent on the previous year's price. In figure 5 S and S' is the supply of cotton fiber when improved and unimproved varieties respectively are planted; D is the demand for cotton fiber; and S' is shifted $K\%$ to the left of S as a result of lower fiber yield in old varieties. They estimated demand and supply equations and collapsed them into two dimensions. Hence D was represented by $P = nQ^{\alpha}$, S was represented by $Q = mP_{t-1}{}^{\beta}$, and S' was represented by $Q = (1 - K)mP_{t-1}{}^{\beta}$. In this case n and m are parameters representing all demand and supply shifters, respectively. The change in net social benefits for each year was

$$(6) \quad \int_0^A (D)d(Q) - \int_0^A (S)d(Q) - \int_0^E (D)d(Q) + \int_0^E (S')d(Q).$$

The authors varied elasticities and K-values to test the sensitivity of their results and examine the distribution of consumer and producer benefits. The change in consumer surplus $= P_2BC - P_3FC = P_2BFP_3$. The change in producer surplus $= 0ABP - 0AH$.

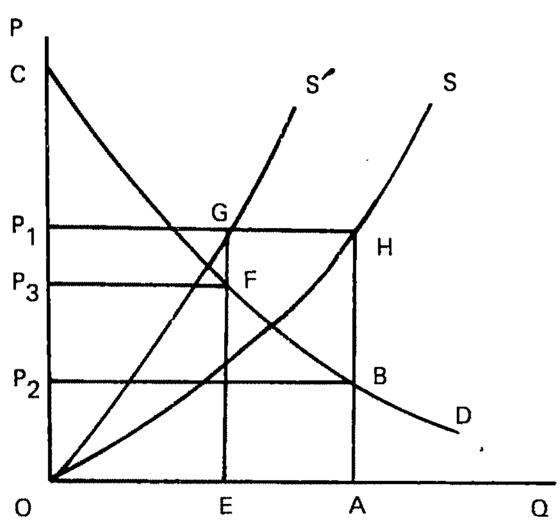

Figure 5. Cotton supply shift resulting from the use of new varieties

Akino and Hayami used a similar approach to estimate social benefits in Japan from rice-breeding research, including distributional effects of rice import policies. In figure 6 actual demand and supply curves are represented by D and S, while S' represents the supply curve that would have existed in the absence of improved varieties. Assuming market equilibrium and no rice imports, the change in net surplus due to research equals $AB0$. The change in consumer surplus = P_nBCP_o. The change in producer surplus = $A0C - P_nBCP_o$. If the government kept the rice price at P_o, the total change would be an increase in producer surplus of $A0C$. Without the increased production due to research, Japan would have to import rice at a total foreign exchange cost of ACQ'_nQ_o to keep the price at P_o

Akino and Hayami provided formulas for estimating P_nBCP_o, ABC, $A0C$, and ACQ'_nQ_o:

$$(7)\quad P_nBCP_o = P_oQ_o\frac{K(1+e)}{e+n}\left[1 - \frac{\frac{1}{2}K(1+e)n}{e+n} - \tfrac{1}{2}K(1+e)n\right],$$

$$(8)\quad ABC = \tfrac{1}{2}P_oQ_o\frac{[K(1+e)]^2}{e+n},$$

$$(9)\quad A0C = KP_oQ_o,$$

$$(10)\quad ACQ'_nQ_o = (1+e)KP_oQ_o,$$

where K is the shift in the production function. The shift in the supply curve can be approximated by $(1 + e)$K.

Scobie and Posada employed the CS approach to study technical change in Colombian rice production. They considered the incidence of research costs and benefits among upland producers, irrigated producers, and consumers in various income groups. They concluded that consumers benefited most, producers suffered overall losses, but small producers lost the most.

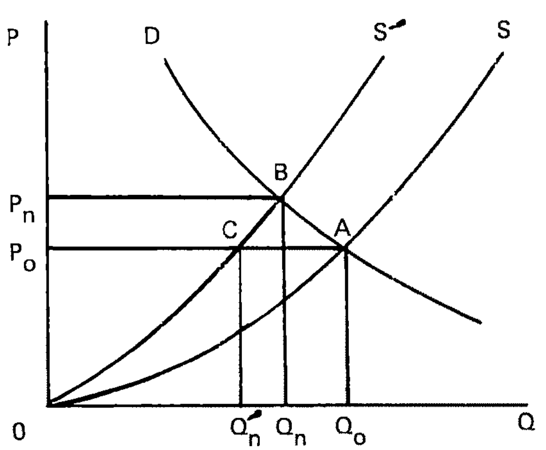

Figure 6. Rice supply shift due to breeding research

Duncan, using new pasture technologies, estimated benefits of research on an input into production of another commodity. The productivity increase shifts the derived demand curve for the input to the right. His expression for calculating social gain under specific assumptions (including a perfectly elastic demand curve) for the final product is $b(Pe^{-Q_1/b} - Pe^{-Q_2/b}) - P(Q_2 - Q_1)$, where b is the long-run price elasticity, P equals input price, Q_1 is old and Q_2 is new input quantity.

Ex post benefit-cost analyses which measure net benefits as increased production valued at constant prices also are in the CS classification (see, for example, Tosterud et al and Kislev and Hoffman). These studies implicitly postulate a perfectly elastic demand curve and a vertical supply curve.

Other studies using the CS approach include Barletta for corn and wheat in Mexico; Hines for corn in Peru; Hertford et al. for rice, soybeans, wheat, and cotton in Colombia; Flores-Moya, Evenson, and Hayami for rice in the Philippines; Nagy and Furtan for rapeseed in Canada; and Pinstrup-Andersen for effects of new agricultural technology on consumers at various income levels.

Lindner and Jarrett (1978) recognized that total benefits are influenced by the nature of the supply curve shift. They hypothesized that some innovations are more likely to generate divergent and others convergent supply shifts. Parallel shifts also are possible. Their reasoning focused on the effects of different types of innovations (biological, chemical, mechanical, and organizational) on average costs of marginal and inframarginal firms and the location of those firms on the industry supply curve.[1]

In their 1978 paper, Lindner and Jarrett provided a generalized formula for measuring research benefits. It avoids some of the biases arising from specific assumptions about supply shifts and elasticities. Utilizing figure 7,

[1] Lindner and Jarrett (1978) use the term inframarginal for the more profitable, lower cost firms. Rose, however, argues that the rent components in supply price makes it difficult to link given firms with particular points on the supply curve.

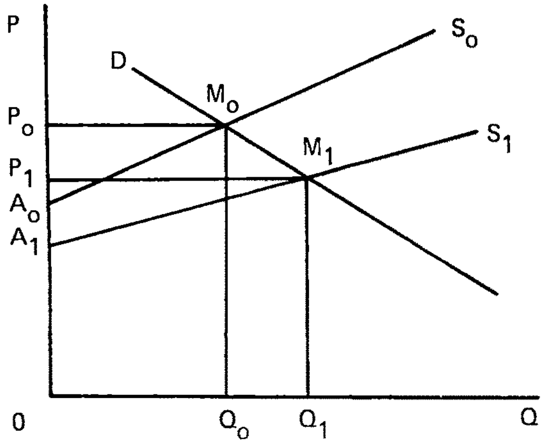

Figure 7. Lindner and Jarrett's research benefits

(12) change in total benefits
$$(A_1M_1M_oA_o) = \tfrac{1}{2}(P_oQ_1 - P_1Q_o + Q_oA_o - Q_1A_1),$$

(13) change in producer benefits
$$= \tfrac{1}{2}(Q_oA_o - Q_1A_1 - P_oQ_o + P_1Q_1), \text{ and}$$

(14) change in consumer benefits
$$= \tfrac{1}{2}(P_oQ_1 - P_1Q_o + P_oQ_o - P_1Q_1),$$

where P_o and Q_o are current price and quantity; $P_1 = P_o\left(1 - \frac{ke}{e+n}\right)$, $Q_1 = Q_o\left(1 + \frac{ken}{e+n}\right)$, where k is the absolute cost reduction at Q_o divided by P_o, e and n are the price elasticities of supply and demand, respectively (n is an absolute value); $A_1 = A_o(1 - K)$ for a proportional shift, $A_1 = (A_o - R)$, where R is the absolute reduction in average costs for all firms for a parallel shift, and $A_1 = A_o$ for a pivotal shift.

Lindner and Jarrett made a computational error which was subsequently pointed out by Rose and by Wise and Fell. Lindner and Jarrett (1980) point out that it arose because their equations apply only when the supply and demand curves are linear. Their calculation of P_1 and Q_1 from P_o and Q_o using a value of the local elasticity of supply implied by the chosen values of A_1 relative to P_1 and Q_1 violated the linearity assumption. Rose and Wise and Fell suggested inclusion of a kink in the S_1 curve directly below M_o to handle this problem (figure 8).

Rose proposed the following equation to estimate the change in total net social surplus:

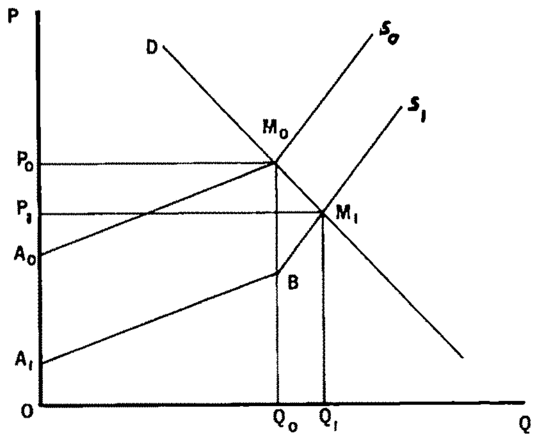

Figure 8. Rose's kinked supply curve

(15) change in total net social surplus
$$= \tfrac{1}{2}Q_o(KP_o + A_o - A_1) + \tfrac{1}{2}KP_o(Q_1 - Q_o),$$

where the first term represents the area $A_oM_oBA_1$ and the second term corresponds to M_oM_1B. For a parallel shift, this reduces to

(16) change in total net social surplus
$$= KP_oQ_o + \tfrac{1}{2}KP_o(Q_1 - Q_o).$$

For a pivotal shift it is

(17) change in total net social surplus
$$= \tfrac{1}{2}KP_oQ_o + \tfrac{1}{2}KP_o(Q_1 - Q_o).$$

The above discussion illustrates the extent to which CS studies have differed in specification of supply and demand functions and in the nature of supply function shifts. The various formulas presented here and others in the literature (for example, Barletta, Dalrymple, Ramalho de Castro, and Ardila) reflect these differences as well as alternative "K"-value derivations. The major differences and relative importance of shift, elasticity, and K-value assumptions underlying the Griliches (1958), Peterson (1967), Hertford and Schmitz, Akino and Hayami, Lindner and Jarrett (1978), and Rose formulas are summarized below.

Griliches assumed a parallel shift (horizontal or vertical); Peterson a proportional shift; Hertford and Schmitz a parallel shift; Akino and Hayami a pivotal shift; and Lindner and Jarrett and Rose four shifts. The nature of the shift assumed is very important. Divergent shifts result in fewer benefits to producers than either parallel or convergent shifts. Duncan and Tisdell have shown that producer returns will be negative when research leads to a divergent supply shift if demand is inelastic.

Lindner and Jarrett (1978) assert that these assumptions predetermined Akino and Hayami's conclusions about the distributional effects of Japanese rice breeding.

Griliches, Hertford and Schmitz, and Lindner and Jarrett assumed linear supply and demand curves. Peterson assumed a general specification. Akino and Hayami assumed constant elasticity supply and demand curves and Rose a linear kinked supply curve and a linear demand curve. These differences are less important than the type and magnitude of the supply shift.

The size of K is a major determinant of net benefits. In some cases K has been measured as an output effect (horizontal shift in the supply curve) and in others as a cost effect (vertical shift in the supply curve). The Hertford and Schmitz formula includes K as a horizontal shifter. Lindner and Jarrett (1978) and Rose used it as a vertical supply curve shifter. Akino and Hayami used K as a production function shifter. Peterson measured K as the proportional change in equilibrium quantity following the supply shift. This is less than Hertford and Schmitz's horizontal distance between the supply curves because of the fall in equilibrium price.

Equation (3), (18), (19), and (20) illustrate differences in the various total net social surplus formulas due to shift, functional form, and K values.

(18) Change in total net social surplus

$$= KP_1Q_1\left(\frac{1}{1+e} + \tfrac{1}{2}\frac{K}{e+n}\right).$$

Equation (18) was derived from Akino and Hayami's results, converting their production function shifter to a supply function shifter; P_1 and Q_1 are equilibrium quantity and price after a rightward supply shift. It is similar to equation (3) from Hertford and Schmitz. The additional e occurs because Akino and Hayami assumed a pivotal rather than parallel shift and a constant elasticity rather than linear supply curve. Had they assumed a linear supply curve, the first bracketed term would have equaled 1/2. Had they assumed linearity and a parallel shift, the two equations would be the same.

Equations (19) and (20) represent a parallel and a pivotal supply shift, respectively. They were derived from equations (16) and (17).

(19) Change in total net social surplus

$$= KP_oQ_o\left(1 + \tfrac{1}{2}\frac{ke}{e+n}\right).$$

(20) Change in total net social surplus

$$= KP_oQ_o\left(\tfrac{1}{2} + \tfrac{1}{2}\frac{ken}{e+n}\right).$$

These equations differ from (3) and (18) because P_o and Q_o are equilibrium price and quantity before the supply shift. Also, K is a proportional vertical shift in the supply curve. It could be converted to a horizontal shift since $K = ke$ (Lindner and Jarrett 1978).

Peterson's formula measures the area below the demand curve between the old and new equilibrium quantity to approximate the area between the supply curves. With a perfectly inelastic supply curve, it is identical to Hertford and Schmitz's equation (3). Griliches's formulas are special cases of equation (3) in the perfectly inelastic and of Lindner and Jarrett and Rose in the perfectly elastic supply case where new equilibrium price and quantity are used in the derivation of K and where $n = 1$.

The demand elasticity is also important because the more inelastic the demand curve, the more likely producers will lose following technical change. Also, if the supply elasticity is absolutely larger than the demand elasticity, consumers will tend to receive a larger share of the benefits than producers. In addition, those technologies which do not directly displace labor can do so indirectly as a result of a fall in the product price if the demand elasticity is low. Binswanger (1980) stressed the importance of general equilibrium effects on factoral income distribution. With the exception of a comment by Musalem, a reply by Ayer and Schuh (1974), and Just and Hueth's analysis of welfare effects of changes in economic surpluses in intermediate markets, general equilibrium effects have been ignored in CS evaluation. The basic flexibility of the CS approach can be a liability if underlying relationships and policies are not accurately mirrored in the analysis.

Production Function Approach

The basic model used in the production function (PF) approach has been

$$(21) \qquad Q = A \prod_{i=1}^{m} X_i^{\beta_i} \prod_{j=0}^{n} R_{t-j}^{\alpha_{t-j}} e^{v},$$

where Q is value of agricultural output, A is a shift factor, X_i is the ith conventional production input, R_{t-j} is expenditure on research (and extension) in the $t-j$th year, β_1 is the produc-

tion coefficient of the ith conventional input, α_{t-j} is the partial production coefficient of research (and extension) in the $t-j$th year, and u is a random error term.

A major source of variation among PF studies is the length and shape of the time lag reflecting the impact of research expenditures on output. Early studies, such as the pioneering work by Griliches (1964), used either a single year's lagged expenditure or a simple average of two previous years. In more recent U.S. studies, Evenson (1967), Fishelson, and Cline and Lu have used an inverted 'V' or 'U'-shaped distribution with a mean lag of six to seven years.

The model of equation (21) has been estimated mainly with cross-section data. Aggregate output was used by Griliches (1964) and Davis for the United States and Kahlon et al. for India. Others applied the model to commodity groups, for example, Peterson (1967), Bredahl and Peterson, and Norton. The latter two studies estimated the marginal internal rate of return (MIRR) to each of four commodity groups (cash grains, dairy, poultry, and livestock) and suggested how to increase the overall rate of return by reallocating research dollars from relatively low to relatively high payoff commodities.

Time-series studies often display an alternative specification:

$$P = AW^{\gamma}E^{\epsilon}\prod_{j=0}^{n} R_{t-j}^{\alpha_{t-j}}e^{v}, \tag{22}$$

where P is a productivity index of agricultural output; W is a weather index; E is a measure of the education level of farm workers; and γ, ϵ are productivity coefficients for the associated inputs.[2]

Most studies used a Cobb-Douglas specification. High intercorrelation problems with time-series data for conventional production inputs and the general lack of sufficient data for the important conventional inputs are major reasons for the use of a productivity index as the dependent variable.

Evenson (1967) first used this model to calculate the marginal product of research in the United States. Cline and Lu updated and refined Evenson's work for aggregate agricultural output and for ten production regions.

[2] Duality approaches using cost or profit functions provide alternative means of analyzing time-series data and have been used by Binswanger (1974), by Gollop and Jorgenson, and by others to analyze technical change. They have not been used as yet to calculate the payoff to agricultural research, however, and therefore are not discussed in this review.

The quality of various productivity indices is always in question. Evenson (1978) presented his own alternatives to officially published series of the U.S. aggregate index for 1870 to 1971, for regional indices for 1927 to 1971, and for individual state indices for 1949 to 1971. He analyzed the relationships between productivity and investment in (*a*) agricultural invention, (*b*) education, and (*c*) research and extension. Evenson divided the United States into geoclimatic regions and attempted to isolate spillover effects of research between different states. The research expenditure for each region was measured using commodity group research expenditures and output value proportions. His results showed a significant spillover effect between states. Evenson, Waggoner, and Ruttan also tested the impact of decentralizing scientists in substations. They found that decentralization of research within a state had a positive effect on productivity of state systems. Flores-Moya, Evenson, and Hayami; White and Havlicek; and others also analyzed the spillover of research among states, regions, and countries.

While all PF studies discussed above used research (and extension) expenditures as the measure of research, specific items included have varied considerably. For example, U.S. studies have ranged from that by Bredahl and Peterson which used only commodity-specific research expenditures by the state experiment stations to that by Cline and Lu which used total research and extension expenditures by experiment stations, the USDA, and the soil conservation service. Alternatively, Evenson and Kislev (1973, 1975) and Evenson (1974) used the number of scientific publications as a proxy for research. Evenson also separated expenditures into commodity-specific applied research and noncommodity-specific, agriculturally related basic research. Evenson and Binswanger included separate variables to measure effects of applied research and basic, science-oriented research.

The PF approach is useful for separating the production effects of research from those of education and conventional inputs among geographical areas. It also allows estimation of marginal as opposed to average rates of return. Difficulty in obtaining data on production inputs such as labor, machinery, and chemical applications by commodity remains a major limitation. Another is the uncertainty of projecting past rates of return into the future. Davis provided evidence that the production coefficient on the research variable in aggre-

gate agricultural production functions has declined since the 1950s, but remained stable since 1964. Finally, PF studies have treated research as an exogenous variable, a generally questionable assumption.

National Income Approach

Tweeten and Hines calculated how much lower the national income would be if the percentage of people on farms was still the same as in 1910 and the resulting additional farmers had the income of today's farmers instead of today's nonfarmers. They estimated the costs of public and private research, education, and federal programs. Then they calculated a benefit-cost ratio.

The larger the gap in earnings between farm and nonfarm workers and the higher the migration rate off the farm, the higher the returns to agricultural research and extension will be under this procedure. Marginal returns to research approach zero as the farm population stabilizes.

Nutritional Impact Approach

Pinstrup-Andersen, Londoño, and Hoover developed a procedure to estimate the nutritional implications of alternative commodity priorities in agricultural research policy. The model estimates the distribution of commodity supply increases among consumers, the related adjustments in total food consumption, and implications for calorie and protein nutrition.

Their model has two phases: (*a*) a price elasticity of demand matrix for various income strata and for the whole market and (*b*) the distribution of a hypothetical supply increase among income strata with resulting adjustments in consumption of other goods which impacts on calorie and protein nutrition.

Ex Ante Evaluation

Ex ante studies can be classified into four groups: (*a*) those using scoring models to rank research activities, (*b*) those employing benefit-cost analysis to establish rates of return to research, (*c*) those using simulation models, and (*d*) those using mathematical programming to select an optimal mix of research activities.

Scoring Models

In 1966 the National Association of State Universities and Land Grant Colleges-U.S. Department of Agriculture (NASULGC-USDA) published a study of U.S. agricultural and forestry research programs. A task force evaluated the strengths and weaknesses in the research program, identified future research problems, and recommended a level of public research investment for the next few years. A simple scoring model (SM) was used to determine the extent to which each research problem area met specified weighted criteria, although it was not employed on a systematic basis to arrive at the final estimate of research needs presented in the NASULGC-USDA study (Williamson). A major result of the study was the systematic classification of research problem areas now used in the USDA's Current Research Inventory System (CRIS).

Mahlstede, and Paulson and Kaldor reported on an SM program at Iowa State University "to ensure the greatest return for the research money spent at the experiment station" (Mahlstede, p. 327). First, administrators and department heads set goals of growth, equity, and security. Then research was classified into three major areas: commodity, resource, and agricultural management research. These areas were divided into nineteen subareas, and a panel was assigned to each to identify research alternatives and estimate the costs. Finally, a scoring procedure was used based on ten criteria including the probability of success. "The validity of the study rests heavily on the premise that scientists, through a systematic group effort, can predict, to some degree, the outcome of scientific inquiry and, thus, improve the basis for selecting research activities that will offer the highest return" (Mahlstede, p. 327).

Shumway and McCracken reported on a model used at the North Carolina Agricultural Experiment Station to determine the emphasis on each of several research problem areas (RPA) defined by the USDA CRIS classification. "The key actors in the study included the experiment station administration, two department head committees concerned with research planning and program implementation, twenty interdisciplinary faculty task forces, eighteen extramural scientist panels, and twenty-three academic departments" (Shumway and McCracken, p. 714). Each of the last three groups either rated or scored problem

areas or recommendations of other groups. A simple SM was used along with a Delphi procedure. Shumway and McCracken noted little consistency within or among groups of scorers. Schuh and Tollini point out that less attention was given to setting goals in the North Carolina procedure than was done in Iowa.

The NASULGC-USDA, Iowa, and North Carolina scoring models are conceptually simple but labor-intensive requiring frequent meetings among people for whom the opportunity cost of time is high. They have the advantage of incorporating benefits and goals that are difficult to quantify by most other procedures, but rankings are not independent of the rating scheme.

Ex Ante Benefit-Cost Approach

Several studies, conceptually analogous to *ex post* CS studies, calculated rates of return or benefit-cost (BC) ratios to proposed agricultural research. It is difficult to predict payoffs to individual projects because of the stochastic nature of research payoffs. Hence, a major difference among *ex ante* BC studies is the projection of yield increases or cost reductions.

Fishel (1971b) described a computerized model for collecting and processing information needed to evaluate research activities and to select an efficient allocation of resources. The model, called Minnesota Agricultural Research Resources Allocations Information (MARRAIS), involved three major steps: specification, estimation, and analysis. Project selection was left to the decision maker. Benefit-cost ratios, benefits minus costs, and internal rates of return were calculated by computer to obtain the needed information. Surveys were sent to numerous scientists in fields related to the proposed research project. They estimated average annual expenditures, time requirements, and technical feasibility. Subjective probability distributions of costs and values were generated for alternative levels of expenditures via a Monte-Carlo sampling procedure. MARRAIS is a sophisticated research evaluation model whose complexity may generate higher costs than simpler models.

Ramalho de Castro and Schuh presented a model focusing on growth and distributional effects of technical change along with direct and indirect effects of research. They set four goals for the research program, assumed a shift in the supply curve for various crops caused by technological change, compared distributional effects on consumers and producers, and examined implications of factor scarcity on desired research direction. They discussed effects of technological change in agriculture on the nonagricultural sector and the effects of economic policies on social benefits and costs of research. Their model minimizes the burden on scientists because it relies primarily on secondary data to project yield increases, adoption rates, and probabilities of success.

Taking a different approach, Easter and Norton used scientists' estimates of yield and cost effects of various research and expected adoption rates of new technologies to apply BC analysis to the land grant universities' 1978 USDA budget requests for soybean and corn production research. A 10% discount rate was applied, harvested acreage was held constant, and a specific set of prices was assumed. An important aspect of the analysis was the BC ratio's sensitivity to variations in probabilities of success, expected yield increases, product prices, and lags between research expenditures and availability of results. Sensitivity analysis provides decision makers with information on the importance of added precision in the evaluation. Effects on prices received by farmers, meat prices, and prices of fats and oils were estimated with impact multipliers from another study.

Araji, Sim, and Gardner conducted a similar type of evaluation for various commodities in the western United States. They conducted interviews with agricultural researchers and extension specialists to determine initiation and termination dates for research projects, probability of research success, probability and rate of adoption of research results (with and without extension), and the resources required to adopt and maintain the new technology. Yield, quality, and production cost changes resulting from the new technology were estimated, as were flows of benefits and costs, BC ratios, and internal rates of return for each project. They also estimated the productivity reduction which would result from eliminating maintenance research and used price flexibilities to determine effects on prices and consumer expenditures.

In another study, Eddleman (pp. 34–35) made use of multipliers from a national input-output analysis to measure secondary impacts of an increase in agricultural productivity.

Gross benefits were the changes in other sectors' output resulting from increased agricultural output. Net benefits were wage increases caused by expanded employment plus net profit gains in each sector.

The key to useful *ex ante* BC analysis is cooperation between physical and social scientists. If cooperation is present, rates and distributions of returns can be assessed relatively quickly. As with *ex post* CS analyses, assumptions made about demand and supply elasticities have important distributional implications.

Simulation Approach

Many researchers have constructed simulation (SI) models for research evaluation. Pinstrup-Andersen and Franklin described the basic components of an SI model for predicting relative contributions and costs of alternative research activities. Their first step is to establish overall goals. This is followed by an identification of changes in product supply, input demand, and farm consumption necessary to achieve those goals. Then research problems and alternative technologies to solve them are identified. The next step is to estimate the time, costs, and probabilities involved in research and farm adoption of the alternative technologies. Estimation of effects on farm consumption, product demand, and input-supply follows. Finally, specification of technology to be developed and scientists' working objectives are established. These steps require an extensive amount of data and estimation of numerous mathematical relationships.

Lu, Quance, and Liu formulated an SI model with R&E expenditures as a principal decision variable. Agricultural productivity changes were attributed to lagged values of production-oriented public agricultural R&E investments, changes in farmers' education, and weather. They used the model to project agricultural productivity growth under three alternative R&E investment growth rate scenarios. They also estimated BC ratios and internal rates of return to R&E investments. Knutson and Tweeten employed a similar model using the USDA-ESCS National-Interregional Projections (NIRAP) System to project farm output and prices resulting from projected changes in productivity.

White, Havlicek, and Otto analyzed investment patterns for agricultural productivity growth. They first estimated effects of research and extension on aggregate U.S. agricultural productivity with a time-series production function. Then they used control theory to determine optimal research expenditures for a given rate of increase in farm prices under selected conditions. Finally they examined effects of reduced research funding on consumer food expenditures and on taxes.

Scobie (1979) developed an SI model including a production function, supply and demand functions, and a discounted cash flow analysis to determine the optimal level of agricultural research investment. Output was assumed to grow at a given minimum rate without research. As research investment increased, the output growth rate increased but at a diminishing rate becoming asymptotic to a maximum rate. By varying assumptions about lags, functional forms, etc., he estimated annual research investments that would generate various internal rates of return.

SI models are more widely used for research evaluation in the private sector than for public agricultural research evaluation. Perhaps this is because the industrial research process is better understood and/or more tightly planned and controlled. Also, private research and development is likely to be less uncertain in its payoffs being more "applied" and less "basic" than public research.

Kislev and Rabiner feel that the research evaluator should try to identify and incorporate factors affecting process in given research lines. Using the Israeli dairy herd as an example, they built an SI model of a breeding program incorporating principles of quantitative genetics, decision variables, and natural constraints to selection. They defined an ideal breeding model and attempted to explain the gap between the real breeding program and the ideal system. This information is useful for *ex ante* evaluation because it provides a guide to constraining factors in research.

SI models are flexible. They can be used to estimate (*a*) optimal levels of research at a national, commodity, or program level, and (*b*) effects of research on prices, income, employment, or other parameters. Unless the models are extremely naive, however, their construction requires much time and information.

Mathematical Programming Approach

Two studies have used mathematical programming (MP) to determine optimal allocation of a given research budget. Russell devel-

oped a model called the Resource Allocation System for Agricultural Research (RASAR) to assist in selecting a portfolio of government-sponsored agricultural research projects in the United Kingdom. He first established an overall goal of outputs "needed to permit the attainment of an ideal state for social welfare" (p. 34). Three dimensions of this goal were identified (consumption, security, and equity) along with nine aspects of these dimensions and a rating system. He used an MP model to maximize utility from the research program. It provided information on (*a*) the set of projects in the research program, (*b*) financing for each project, (*c*) the marginal utility derived from investing in extra units of resources for the program and each project, and (*d*) the sensitivity of project selection to varying weights on goals. The system was tested on a group of projects at Scottish research establishments.

Cartwright developed a model focusing on research resource allocation within an agricultural economics department. He analyzed the problems of choosing major research areas and specific research jobs. To analyze the former, he developed a nonlinear integer programming model which used a staff preference function and information on (*a*) researcher time, (*b*) funds that new research areas would bring into the department, and (*c*) new staff positions that would be created. The job selection model also assumed a centralized decision process and required similar information.

A major difficulty in using MP to guide research resource allocation is that a preference function must be specified. Only this and the SM approaches require elicitation of decision makers' preferences.

Conclusions and Implications

Optimal research resource allocation depends on the market for research results and technological characteristics of the process itself. Private firms underinvest from society's viewpoint in many types of agricultural research because knowledge generated cannot be fully appropriated by the firm producing it. Research, especially basic research, is inherently risky. Governments recognize this and invest substantially in agricultural research.

Many approaches are used to evaluate public research investments. No one approach is superior in all situations. While it is possible to develop a theoretical model to incorporate all relevant research evaluation issues, such a model would consume enormous resources and time. Therefore, it is useful to compare approaches, drawing conclusions about their strengths, weaknesses, and ability to answer different questions. Several relevant comparisons are shown in table 1.

Goals must be established before research priorities can be set. Goals exist at various levels and often conflict. A single research project usually bears on multiple goals. The more normative the study, the more important it is to elicit and quantify trade-offs among goals of relevant decision makers. For this reason, SM and MP approaches usually involve some elicitation of goals. All research evaluation studies, however, deal implicitly, if not explicitly, with goals. Many CS and *ex ante* BC studies, recognizing that equity may be an important goal, have examined distributional effects on consumers and/or producers. The CS and *ex ante* BC approaches can most easily provide this information.

The PF technique is best for examining effects of research on the relative productivity and income shares of input categories. Few studies have accounted for secondary impacts such as displaced resources, environmental effects, or regional impacts, but CS, *ex ante* BC, SM, and SI approaches can do this.

Economic policies affect returns to agricultural research. Theoretically, policy can be included in every one of the approaches. The PF approach does it implicitly, while the others may do it explicitly.

It is evident from table 1 that several alternative techniques can be used to answer given questions. The choice of which to employ will be affected by their relative time costs. A quick look at cost characteristics, table 1, indicates why CS, PF, and *ex ante* BC approaches are the most widely used quantitative agricultural evaluation tools. Time costs partly explain why nonquantitative, completely subjective evaluation is so common.

Can more quantitative analysis of benefits and costs improve the decision-making process and, if it can, is it worth the cost? Some argue that there is so much serendipity involved in research, that *ex ante* evaluation of research resource allocation is meaningless. Clearly, there is the danger of dampened incentives and creativity if research is "overmanaged." It is difficult to predict high payoff projects using any of the techniques in table 1, especially in basic research where relevance and value may not be readily apparent. *Ex post* rates of return estimated by the CS and

Table 1. Comparison among Major Agricultural Research Evaluation Techniques

	Ex Post Techniques[a]		*Ex Ante* Techniques[b]			
Characteristic	CS	PF	SM	BC	SI	MP
1. Requires explicit elicitation of goals.	no	no	usually	no	no	yes
2. Can determine distributional effects on consumers and producers at various income levels.	yes	no	no	yes	yes	no
3. Can determine effects on relative productivity of input categories.	no	yes	no	no	yes	no
4. Can consider secondary impacts of research on employment, environment, nutrition.	some	no	yes	some	yes	no
5. Can consider tradeoff among goals.	no	no	yes	no	yes	yes
6. Can consider economic policy and trade effects.	yes	yes	yes	yes	yes	yes
7. Relative cost in researcher's time.	low	interm.	interm.	low	high	interm.
8. Relative cost in scientist's time.	low	low	high	interm.	interm.	interm.
9. Relative cost in administrator's time.	low	low	high	low	low	interm.
10. Relative data requirement.	low	high	low	low	variable	interm.
11. Can consider value of maintenance research.	yes	no	no	yes	yes	no
12. Can evaluate benefits to "aggregate" research.	yes	yes	no	yes	yes	no
13. Can evaluate benefits to "commodity" research.	yes	yes	yes	yes	yes	yes
14. Can evaluate benefits to research projects or program.	yes	no	yes	yes	yes	yes
15. Can evaluate benefits to "nonproduction" or "noncommodity"-oriented research.	In some cases	no	yes	In some cases	In some cases	yes
16. Can provide ranking of research projects based on multiple goods.	no	no	yes	no	no	yes
17. Can handle uncertainty.	with sensitivity analysis	with diffic.	yes	yes	yes	yes
18. Can consider the lags involved in research and adoption.	yes	yes	yes	yes	yes	yes
19. Can quantify public sector-private sector interaction.	no	some	no	no	some	no
20. Can quantify research-extension interaction.	no	some	no	no	some	no
21. Can quantify spillover effects.	no	yes	no	no	yes	no
22. Usually estimates marginal rate of return.	no	yes	no	no	sometimes	no
23. Usually estimates average rate of return.	yes	no	no	yes	sometimes	no
24. Calculates return while statistically holding nonresearch inputs constant.	no	yes	no	no	sometimes	no
25. Usually require computer.	no	yes	no	no	yes	yes
26. Can help identify or quantify factors most affecting progress in given research line.	no	no	yes	yes	yes	no
27. Can be used to evaluate basic research.	no	some	some	no	some	no

[a] CS is consumer-producer surplus approach; PF is production function approach.
[b] SM is scoring model approach; BC is *ex ante* benefit cost approach; SI is simulation model approach; MP is mathematical programming approach.

PF approaches document a general underinvestment in agricultural research. These results can be and have been used to support state and national budget requests.

These techniques vary in needed data. The PF technique typically requires much data, usually secondary. On the other hand, the SM requires little, but costly, primary data.

Few studies have measured the value of maintenance research. The maintenance of crop and livestock yields over time probably reflects a larger proportion of total research benefits and could be measured most easily with the CS approach.

Evaluation of research may occur at the aggregate, commodity, and project levels. The PF approach has little value at the project level where SM and MP approaches are potentially most applicable. A major problem in evaluating noncommodity research is defining and measuring the output. In general, the output is information rather than improved input

quality. Potential exists for using CS and *ex ante* BC analyses to quantify returns to such research.

Uncertainty can be incorporated, but it considerably complicates the PF approach. Time lags can be considered, although their statistical estimation is feasible only with the PF approach. No approach permits accurate measurement of public-private or the research-extension interactions. Research spillover from one area to another can be quantified with production functions and with some types of simulation.

Not all approaches involve rate-of-return calculations. A marginal rate of return can be readily calculated using a production function, while CS and *ex ante* BC analyses usually provide average rates of return. Being statistical methods, the PF and SI approaches can hold nonresearch inputs constant in an analysis.

SM, SI, and *ex ante* BC models can be used to identify and quantify factors affecting progress in given research lines. None do a good job evaluating basic research.

A rich set of evaluative procedures have been developed, but additional work is needed. Three areas in need of further methodological work are (*a*) the evaluation of noncommodity research, (*b*) analysis of factors affecting progress in given research lines, and (*c*) the study of private-public interaction in agricultural research, including transmission of research results to farmers.[3]

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[3] Other evaluation issues are discussed in the proceedings of a recent symposium on research evaluation methodology (Norton et al.).

Note: An additional list of 135 categorized references providing other examples of the techniques described is available from the authors.

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Editor's Note

Two lines of type were inadvertently omitted from the article, "Farmers' Credit Risks and Liquidity Management," written by Barry, Baker, and Sanint in the May 1981 issue of the *Journal*. The omission occurred on page 219, 5 lines above equation (13a), where two lines of type are repeated. The full sentence, which should replace the incorrectly repeated lines and conclude the paragraph, is: "The value of $\hat{\sigma}_{ri}$, then, is .00013, which requires a higher covariance in order for debt use in expression (11) to exceed its value in (7)." The editors apologize.

Notes

Impact of Corn Prices on Slaughter Beef Composition and Prices

Enrique Ospina and C. Richard Shumway

The purpose of this paper is to examine the relationships between feed grain prices and the beef product mix. An annual econometric model of the U.S. livestock industry (Ospina and Shumway 1979, 1980) is used to evaluate the impact of corn price changes on the composition of slaughter beef supplies and the relative prices of the quality categories by analyzing the reduced-form dynamic multipliers.

The structural form of this model disaggregates beef demand among three quality components (U.S. Department of Agriculture [USDA] grades prime and choice, good, and standard-and-lower, labeled for convenience as choice, good, and utility, respectively).[1] Supplies are disaggregated among the same quality categories and also among sex categories (steers, heifers, and breeding herd culls). Simultaneity is modeled in the demand, supply, and inventory decisions. Pork and broiler functions are incorporated. The separate effects of current and expected prices on supplies are differentiated, and feed grain prices are assumed to be exogenous.[2] All functions are linear, and the analysis is at the carcass level.

Three changes were made in the earlier model, and its parameters are reestimated (Ospina and Shumway 1981). The changes include the following. (*a*) Three subsequent years of data are added, thus making a twenty-three-year data period, 1956–78. (*b*) Because important changes in USDA beef grades took place in early 1976 which affected the choice and good grade definitions (Nelson), an intercept dummy variable is added to these supply and demand equations to account for its impact. (*c*) A relatively minor change is made in the disaggregation of data among the good and utility beef categories.[3]

The change in USDA grade definitions significantly increases the supply of choice beef and decreases the supply of good beef. The estimated parameters of the grade change dummy variables have expected signs and low standard errors in five of the six structural equations to which they are added.

Several substantive differences from the earlier estimation occur in the magnitudes of individual parameters because of the additional data and other modifications. However, parameter signs and the earlier general conclusions are stable. In particular, the aggregate short-run beef supply response remains positive (this finding contrasts with the conclusions of some earlier writers, e.g., Reutlinger, Tryfos), and the supply response to a 1% decrease in corn price remains greater than the response to a 1% increase in beef prices. At 1978 prices, the elasticities of beef supply are estimated to be -0.23 with respect to corn price and $+0.15$ with respect to average beef price. These estimates are similar to our earlier estimates of -0.25 and $+0.14$, respectively, at mean 1956–75 prices.

Reduced-Form Model

The reduced-form model was derived and the stability conditions of the model determined (Theil and Boot, p. 144). The model is stable; the absolute

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[1] Many models, varying in scope and refinement, are available in the literature. Reutlinger disaggregated beef production data among sex categories (steers, heifers, cows, and bulls). Langemeier and Thompson, Freebairn and Rausser, Folwell and Shapouri, Shuib and Menkhaus, and Arzac and Wilkinson disaggregated by quality into fed and nonfed beef groups. All have incorporated grain prices in the fed beef supply function, but the relation of nonfed beef supplies and grain prices generally has not been explored.

[2] While supply and demand functions are assumed to depend on current prices, inventories are functions of expected prices. Proxies for expected prices in the model include (*a*) lagged prices, and (*b*) prices predicted by polynomial distributed lag model, both consistent with the period of decision making (Ospina and Shumway 1979, pp. 49–50).

[3] In the data for the original model, nongraded standard beef was assumed to be the same percentage of nongraded beef as graded standard beef was of graded beef (Ospina and Shumway 1980, pp. 23–24). Because this appears to underestimate the quantity of slaughter beef that would have graded standard or lower, if all beef were graded, the data are adjusted for this paper by assuming the same standard-to-good ratio in both graded and nongraded supplies. This results in somewhat larger estimates of utility beef, but only a small percent reduction in good beef. Functional forms, underlying assumptions, and variable definitions remain as in the original model. The data sources are the same as previously used (U.S. Department of Agriculture 1965–79a, b, c, 1979; U.S. Department of Commerce 1971, 1971–79).

value of each of the characteristic roots (two real roots, .39 and −.69) of the reduced-form coefficient matrix of the lagged endogenous variables is less than unity. The system exhibits dampening oscillations, and the paths of the endogenous variables are convergent.

Corn Price Multipliers

The dynamic multipliers were estimated following Theil and Boot. Table 1 reports estimates of the effects of an increase of $1 per bushel in the price of corn on beef quantities supplied and prices.

The impact multipliers (no lag) indicate that the immediate (current year) total effect of an increase in the price of corn is a reduction in choice beef supplies and increases in good beef and in domestic utility beef supplies. Total slaughter beef supplies decrease. Higher corn price results in increased choice and good beef prices, decreased utility beef price, and increased average beef price.

The delayed multipliers, presented in table 1 for each of six years following a sustained corn price change, depict the dynamic features of the model. Choice beef supplies increase in the next two years after a corn price increase, thus partially offsetting the substantial reduction that occurs immediately. Subsequent differential changes alternate in sign and decrease in absolute magnitude. The initial increase in good beef supplies is further augmented by an increase the year after the corn price increase. Subsequent delayed multipliers move in the opposite direction of choice beef supplies; the absolute value of the multiplier is highest in the second year. For the supply of domestic utility beef, the delayed multiplier has a positive sign the first two years after the corn price increase, and then it alternates in sign each year thereafter. The magnitude of utility beef supply response in the year after the corn price change is more than ten times greater than in the year of the change. This reflects a substantial liquidation of the breeding herd as initial changes in corn price are translated into sustained changes in price expectations. The delayed multiplier for total beef supplies is positive in the first year after the corn price increase, then alternates in sign and decreases in magnitude each year thereafter. The immediate directional movement in total beef supplies is caused primarily by the large changes in choice beef, next, to changes in utility beef, and, subsequently, to changes in the good beef category.

The delayed multipliers for the price of each beef category are negative during the first two years after the corn price increase and positive in the third year. Then they alternate in sign thereafter, always decreasing in magnitude. The strength of the effect of a corn price change on utility beef price may at first seem somewhat surprising since corn price does not enter the structural equation because not much grain is fed to cows prior to slaughtering. This result, however, underscores the effect of corn price on beef breeding herd buildup and liquidation.

The equilibrium (or cumulative) multiplier resulting from a sustained corn price increase implies a large decrease in choice beef supplies, a minor increase in good beef supplies, and a substantial increase in utility beef supplies. The absolute magnitude of the change in choice beef supplies is double that in the other two categories combined. Thus, there is a decrease in overall beef slaughter. The equilibrium multipliers for beef prices indicate an increase in choice beef prices, and a decrease in good, utility, and average beef prices. By far the greatest price change is for utility beef.

Multiplier Effects on 1978 Levels

Choice beef supplies in 1978 were 12,670 million pounds, good beef supplies were 6,578 million pounds, and domestic utility beef supplies were 4,835 million pounds, representing 52.6%, 27.3%, and 20.1%, respectively, of total domestic slaughter beef supplies. Average corn price for 1978 was $2.31 per bushel. An increase of $1 per bushel of corn (43% of 1978 price) reduces current-year choice beef supplies by 21% (to 10,060 million lbs.); it increases good beef supplies and utility beef supplies by 1.4% and 1.9% each (to 6,670 and 4,926

Table 1. Mean Estimates of Multipliers for an Increase of $1 per Bushel in Corn Price

Years	Beef Quantity				Beef Price			
	Choice	Good	Utility	All	Choice	Good	Utility	All
	(1,000 lbs.)				($/cwt.)			
0	−2,609,977.0	91,914.0	91,109.9	−2,426,953.1	5.97	2.48	−7.64	1.65
1	240,675.0	157,140.0	918,367.0	1,316,182.3	−3.49	−3.48	−5.82	−4.09
2	106,024.7	−199,160.9	21,676.6	−71,459.6	−.29	−.86	−1.82	−.82
3	−73,050.7	137,221.8	−14,935.2	49,235.5	.20	.59	1.25	.57
4	50,332.0	−94,545.8	10,290.3	−33,923.5	−.14	−.41	−.86	−.39
5	−34,678.7	65,142.0	−7,090.0	23,373.3	.10	.28	.59	.27
6	23,893.6	−33,882.9	4,885.0	−5,104.3	−.07	−.19	−.41	−.19
Cumulative	−2,306,529.0	131,138.0	1,022,311.0	−1,153,080.0	2.31	−1.51	−14.54	−2.93

million lbs., respectively). Total beef supplies decrease by 10%. The new proportions are 46.5%, 30.8%, and 22.7% for choice, good, and utility beef supplies, respectively. The choice-good beef quantity ratio declines from 1.93 to 1.51, and the choice-utility beef quantity ratio declines from 2.62 to 2.04.

An increase in corn price that is sustained long enough to attain a new equilibrium reduces choice beef supplies by 18% (to 10,363 million lbs.), increases good beef supplies by 2% (to 6,709 million lbs.), and increases utility beef supplies by 21% (to 5,857 million lbs.). Total beef supplies decrease by 5%. The new proportions are 45.2%, 29.3%, and 25.5% for choice, good, and utility beef supplies, respectively. The choice-good beef quantity ratio is 1.54, and the choice-utility beef quantity ratio is 1.77.

Prices in 1978 were $79.78, $75.47, and $65.37 per hundredweight for choice, good, and utility beef, respectively. Following an increase in corn price of $1 per bushel, current-year choice beef price increases by an estimated 7.5% (to $85.75/cwt.), good beef price increases by 3.3% (to $77.95/cwt.), and utility beef price declines by 11.7% (to $57.73/cwt.). The choice-good beef price ratio increases only a little, from 1.06 to 1.10, and the choice-utility price ratio increases from 1.22 to 1.49.

With sustained increase in corn price, choice beef price increases by 2.9% (to $82.09/cwt.), good beef price declines by 2% (to $73.96/cwt.), and utility beef price declines by 22.2% (to $50.82/cwt.). The new choice-good price ratio is 1.11, and the choice-utility price ratio is 1.61.

Elasticities

Total elasticities of beef quantities and prices with respect to corn price are in table 2. These elasticities are derived from the reduced-form equations at 1978 variable levels. They are measures of the general equilibrium elasticities after either all current year or all cumulative adjustments in other variables have been accounted for. Consequently, they differ from partial supply elasticities based on the structural model parameters. Some of the total elasticities for a sustained change in corn price also differ substantially from the total elasticities for a current year change in corn price. Most notable are the elasticities for utility beef quantity and price. This difference occurs because lagged prices are used as proxies for expected prices in the breeding herd inventory demand equation. Thus, the major change in slaughter cow supplies is estimated to occur in the year after the initial change in corn price.

If corn price were to increase 10%, a very small (.4%) current year increase in lean (good and utility) beef supplies would result. It would be accompanied by a substantial (4.8%) decrease in choice beef supplies and an important reduction (2.4%) in the total quantity of beef marketed. Price of utility beef drops considerably (2.7%) but the average price of all beef increases a little (.5%).

A sustained 10% increase in corn price has a major impact on the supply of lean beef (4.9% increase in utility and .5% increase in good beef). The 4.2% decrease in choice beef results in a 1.1% total decrease in beef marketed. Only the price of choice beef goes up (.7%). The price of utility beef drops 5.1% and the average price of all beef goes down .9%. Thus, sustained increases in the price of grain have important implications on the quantity of lean beef marketed, the ratio of choice to lean beef, and the price of utility beef.

Table 2. Total Elasticities of Domestic Slaughter Beef Quantity and Price

	Elasticity with Respect to Corn Price Change[a]	
Category	Current Year	When Sustained
Choice beef quantity	−.48	−.42
Good beef quantity	.03	.05
Utility beef quantity	.04	.49
All beef quantity	−.24	−.11
Choice beef price	.17	.07
Good beef price	.08	−.05
Utility beef price	−.27	−.51
All beef price	.05	−.09

[a] Computed at 1978 levels.

Conclusions

The impact of corn price on composition and prices of slaughter beef was examined from the reduced form of an annual disaggregated econometric model of the U.S. livestock industry. The quality composition and relative prices of slaughter beef categories change dramatically in response to corn price changes. This is true both of current year and long-term effects. The greatest current year impacts of an increase in corn price are decreases in choice beef slaughter and utility beef price. In the long run, a sustained corn price increase will have its greatest influence by decreasing choice beef slaughter, increasing utility beef slaughter, and decreasing utility beef price. The contention that higher grain prices will eventually mean higher beef prices is supported by this analysis only with respect to choice beef. Average beef price actually declines because of a major reduction in quality of beef marketed. Not only are choice beef supplies substantially reduced but lean beef production is increased, and price differentials are widened. Thus, the change in perceived quality is amplified.

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Price Variation in Direct and Terminal Markets for Cattle and Hogs: An Illinois Case

Mahlon G. Lang and Franco Rosa

The increasing importance of direct, as opposed to terminal, livestock markets is well-known. During the 1961–78 period, the nation's share of cattle purchased through direct channels rose from 38% to 73.4%, and the nation's share of hogs sold directly rose from 59.6% to 73.8%.

Pecuniary advantages of direct marketing explain this trend. Changes in the structure of the livestock production and slaughter industries often permit traders to reduce procurement costs through direct purchases. Among these changes are the decentralization of packing firms and the emergence of larger production units. But there is concern regarding the price discovery implications of the trend to direct marketing. This is reflected in research on marketing alternatives for agriculture and in concern about "thin" markets (Hayenga).

The marketing alternatives and thin markets literature is ultimately concerned with the performance consequences of vertical coordination alternatives. While that literature identifies several performance dimensions by which to compare these alternatives, the development of operational performance measures has been slow.

Day-to-day price variation was used to compare performance in Illinois direct and terminal markets for slaughter cattle and hogs. This involved (*a*) the development of a working hypothesis, (*b*) the collection of data with which to test the hypothesis, and (*c*) the analysis and interpretation of these data.

Theory and Hypothesis

In a perfect market, the equilibrium price of a given commodity at spatially separated points will, *ceteris paribus,* differ at most by transfer costs (Bressler and King, p. 89). This assumes (*a*) perfect knowledge by buyers and sellers, (*b*) rational behavior, and (*c*) free entry in all directions (Bressler and King, p. 84). Under these conditions, one also would expect equal day-to-day price variance in spatially separated markets.

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But there are two reasons to expect that observed price variance is greater in direct markets than in terminal markets. These involve market structure and price-reporting practices.

First, market information is more complete in terminal markets than in direct markets. Since terminal market trading is geographically concentrated, price discovery in a given terminal market transaction may be directly affected by several well-informed packer buyers and several commission agents who, as market specialists, represent producers.

In contrast, direct market transactions are geographically diffused. Transactions are consummated at many packing houses, country buying points and individual feedlots. An individual transaction may be directly affected by only one buyer and one seller. While packer buyers may be well-informed, the producer, who is not a market specialist, generally cannot bring as much market information to a direct market transaction as can a commission agent in a terminal market.

Second, direct-market price reports are based on sampling and the reporter's judgement. But terminal-market price reports are based on a summary of virtually all trading at the terminal. Hence, the sampling error is greater in direct market price reports than in terminal reports.

These observations are the basis for the hypothesis that observed day-to-day price variation is greater in direct than in terminal markets. This hypothesis was explored by testing formal hypotheses of equal statistical variance.

Method

Data were secured through the Illinois Federal-State Market News Office. The data include daily prices paid in 1976 to farmers in the Illinois direct and terminal markets for nine classes of slaughter cattle and seven classes of slaughter hogs. Terminal market data reflect trading at Joliet, Illinois. The direct market data represent the market reporters' summary of direct purchases by seven packers and seven order buyers.

The raw data were reported as a daily range of prices for each class of livestock. The midpoint of each reported range was used in the analysis. The midpoint would not be a maximum likelihood price estimator if there were a reporting bias. However,

since variance is independent of scale, this would not affect the measure of day-to-day price variance if one assumes that any reporting bias is consistent.

The data were subdivided by month to reduce the influence of seasonal price variation. Then, to eliminate the effects of within-month trends, a quadratic trend line was estimated for each month, for both markets and for both classes of livestock. In more than two-thirds of the cases, an F-test for the presence of trend was significant at the .05 level.

Results

For cattle, well over half of the monthly comparisons showed greater price variance in direct markets than in terminal markets. For hogs, the reverse was true. While statistically significant, we judge that these differences are not economically significant.

Price Variance around Trend: Cattle

Cattle price data were sufficient to compute 83 direct and terminal market variance pairs. Ratios of the sample variance pairs were used to compute F-statistics with which to test the hypothesis of equal variance.

As table 1 shows, the hypothesis of equal variance was rejected nineteen times at the .10 level in favor of the alternative hypothesis of greater direct market price variance. The same hypothesis was rejected twelve times at the .05 level and two times at the .01 level. In four cases, the hypothesis was rejected in favor of the hypothesis that price variance in terminal markets is greater.

Price Variance around Trend: Hogs

Hog price data were adequate to secure eighty-four direct and terminal market variance pairs. Table 2 shows that the hypothesis of equal variance was rejected twenty-five times at the .10 level, nineteen times at the .05 level, and eleven times at the .01 level. All cases indicated greater price variance in the terminal market.

But of the twenty-five tests in which the equal variance hypothesis was rejected, eighteen were among the two heaviest (330–500 lb.) classes. For this reason, the sixty variance pairs representing the five lighter classes were separated for further analysis.

Further Analysis

The individual tests of equal variance showed a higher variance in the direct cattle market for fifty-six of eighty-three variance pairs. For hogs, forty-seven of sixty variance pairs showed a higher variance in the terminal market.

But, if price variance in direct and terminal markets were equal, one would expect one-half of the variance pairs to show greater variance in the direct market and one-half to show greater variance in the terminal market. To determine whether the sample proportions could have been drawn from such a population, an F-statistic (Yamane, pp. 660–4) was used to test this hypothesis. For both cattle and hog data, the test was rejected at the .01 level. These results are consistent with those of the previous analysis.

Economic Significance

For the period analyzed, the economic significance of these differences is negligible. This is demonstrated by drawing upon extreme cases of statistically different price variation.[1] Producers selling 1,000-pound choice steers in February direct markets would have had one chance in seven of receiving up to 30¢ per hundredweight less than their counterparts in terminal markets. Producers of 200-pound 1- and 2-grade hogs, by selling in January terminal markets, would have run one chance in twelve of receiving up to 19¢ per hundredweight less than producers selling in direct markets. Further, assuming normally distributed price variation, both cattle and hog producers would have had the same chances of gaining up to 30¢ per hundredweight (cattle) and 19¢ per hundredweight (hogs) by dealing in the markets where price variation was greater.

Because the potential losses from selling in the more variable markets were well under 1% of livestock prices at the time of this study, only the extreme risk averter would have changed markets on the basis of these findings. If the economic consequences of selling in the market with a greater price variance were more severe, producers might devote more effort to assembling market intelligence. Their resulting behavior would then drive price variation in the two markets closer together.

Interpretation: An Alternative Hypothesis

These mixed findings require further study. There is one alternative hypothesis which, while conjectural, is based upon discussions with livestock marketing specialists and market reporters who were informed of these findings.

Livestock buyers for a given packer are stationed both at country buying points and terminal markets. The buyers communicate with each other daily. In contrast, all but the most sophisticated livestock producers have less access to market information. This information asymmetry, along with the buying practices discussed below, may explain the mixed statistical results.

On a given day, the aggressiveness with which

[1] These calculations are too extensive for presentation here. Interested persons may write to the authors.

Table 1. Results of F-Tests Comparing Daily Cattle Price Variance around Quadratic Trend, by Month, Illinois 1976

	Steers					Heifers				
Weight and Grade	1100–1300 lb. Prime	900–1100 lb. Choice	1100–1300 lb. Choice	900–1100 lb. Good	1100–1300 lb. Good	900–1100 lb. Prime	700–900 lb. Choice	900–1100 lb. Choice	700–900 lb. Good	Total
Number of pairs of months observed	11	12	9	9	5	12	9	9	7	83
Months during which terminal market variance is greater	3	3	4	4	2	5	2	2	2	27
Months during which direct market variance is greater	8	9	5	5	3	0	0	0	0	56
Months during which terminal market variance is significantly greater at the .10 level	1	0	0	2	1	0	0	0	0	4
Months during which direct market variance is significantly greater										
at the .01 level	0	1	0	0	0	0	1	0	0	2
.05 level	1	2	2	1	0	1	2	1	2	12
.10 level	3	3	3	1	0	2	3	2	2	19

Table 2. Results of *F*-Tests Comparing Daily Hog Price Variance around Quadratic Trend, by Month, Illinois 1976

Weight and Grade	200–220 lb. 1,2 Grade	220–240 lb. 1,2 Grade	240–270 lb. 2,3 Grade	200–220 lb. 1,2,3 Grade	220–240 lb. 1,2,3 Grade	330–400 lb. 1,2,3 Grade	400–500 lb. 2,3 Grade	Total
Number of pairs of months observed	12	12	12	12	12	12	12	84
Months during which terminal market variance is greater	9	10	8	9	11	12	11	70
Months during which direct market variance is greater	3	2	4	3	1	0	1	14
Months during which terminal market variance is significantly greater								
at the .01 level	0	0	1	0	0	5	5	11
.05 level	0	1	1	0	1	7	9	19
.10 level	1	2	2	1	1	8	10	25

buyers must bid to secure needed livestock supplies depends on their estimates of availability. A buyer procuring livestock in two or more locations logically uses the most active location to guide bidding at other locations.

For cattle buyers, terminal yards remain an important single source of supply even though, in total, more of their purchases are made directly at several buying points. They, therefore, use terminal market supplies to guide bidding in direct country buying.

Direct market trading for hogs differs from that for cattle. Direct sales by hog producers are more likely to move to concentrated buying points than directly to slaughter plants. Thus, hog buyers use deliveries to direct buying points to guide their bidding in the terminal yard.

These buying practices may explain differences in price variation in markets for cattle and hogs. When livestock deliveries are low at the buyer's single most important source of supply, aggressive bidding will not bring forth greater supplies at that location on a given day. But at diffused or residual buying points, slightly more aggressive bidding may be effective and probably would cost less on the margin. Alternatively, when supplies are ample at the main source of supply, weaker bidding at residual buying points may occur, securing needed supplies at lower prices.

Since the terminal market is the most important single supply point for cattle, cattle price variation is greater in direct markets. However, because direct country buying points are the most important single source of supply for hog buyers, hog price variation is greater in the terminal market.

This phenomenon would not be expected in the absence of information asymmetry. Sellers possessing information parity with buyers would, with knowledge of supply conditions at major purchase points, anticipate the buyers' pricing moves and sell where more aggressive bidding is anticipated.

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A Disaggregated Analysis of Corn Acreage Response in Kentucky

Michael R. Reed and Steven K. Riggins

One of the most commonly researched areas in agricultural economics is acreage supply analysis. The factors which determine the amount of land farmers plant to various crops are vitally important to farm policy decision makers. The trend in this area of research is clearly toward more disaggregated acreage supply functions. Recent studies by Whittaker and Bancroft, and Morzuch, Weaver, and Helmberger are examples of acreage supply analyses using data on a state-by-state basis. Morzuch, Weaver, and Helmberger argue that "spatial heterogeneity and the opportunity for measuring variables with greater precision might well make disaggregation at least to the state level worth the extra costs of data collection and analysis" (p. 37).

The purpose of this paper is to investigate the gain in explanatory power which can accrue to acreage supply functions for corn when data is disaggregated beyond the state level. This disaggregation not only allows for greater accuracy in the measurement of variables, but also allows the production function to vary by area. A disaggregated analysis should be particularly appropriate for states with a wide range in productivity of farm land.

The approach used in this study is to fit an acreage supply function for corn with substate data, then compare the results with the results of an acreage supply function using statewide data.

Model Specification and Data

The acreage supply for corn specified in this study is

(1) $AC_{it} = f(PC_{it-1}, PS_{it-1}, AC_{it-1}, GP_t)\ i = 1, \ldots, 14,$

where AC_{it} is acres of corn planted in area i in year t (in 1,000 acres), PC_{it-1} is the relative price of corn in area i in year $t-1$, PS_{it-1} is the relative price of soybeans in area i in year $t-1$, AC_{it-1} is acres of corn planted in area i in year $t-1$ (in 1,000 acres), and GP_t is a variable to measure government programs in year t. Relative prices are output prices divided by a fertilizer price. Fertilizer prices are used as a measure of input prices because they are readily available and account for a large proportion of production costs.

We have assumed, using this specification, that producers operate in a perfectly competitive market, making planting decisions in order to maximize expected profits. Lagged relative prices are used to measure the expected relative price in year t. The major crop which competes with corn for acreage in Kentucky is soybeans, so the relative price of soybeans in year $t-1$ was included in the corn acreage function. In addition, it is assumed that producers do not react immediately to changes in factors which influence acreage decisions due to the cost of change and inertia. For this reason, lagged corn acreage is also included as an explanatory variable.

Numerous variable definitions were tried in the model structure to capture the effects of government programs for corn. The results of the various variable definitions will be discussed in the results section. Earlier model specifications had futures prices around planting time in place of lagged prices to measure the price producers expect for corn and soybeans. These futures prices were adjusted using the previous year's basis when such data was available. The results of these earlier specifications were judged inferior to the results reported on the basis of t-values and R^2 values.

The model was applied to acres devoted to corn in Kentucky for the 1960–79 period. The state of Kentucky has a wide variety of agricultural settings. The western section of Kentucky is the cash grain area of the state. Farms are similar to Corn Belt farms, except on a smaller scale. The middle section of Kentucky has been dominated by cow-calf operations for many years. However, the production of grains as a cash crop has increased in recent years. The eastern section of the state is characterized by very limited, subsistence-type farming because of topography.

For the analysis of corn acreage response, Kentucky was broken down into fourteen areas. These are the official extension areas of the state. Areas 1 through 6 are Western Kentucky, the predominantly cash grain area; areas 7 through 10 are Central Kentucky, the areas characterized by cow-calf operations; and areas 11 through 14 are Eastern Kentucky, where farming is rather limited.

Individual area prices for corn and soybeans

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were available for areas 1 through 6 and area 8; prices in other areas were assumed to be the statewide average. Area prices for corn and soybeans were the average price received by farmers in the farm analysis program of Kentucky and were collected from the Kentucky Cooperative Extension Service.[1] Data on the statewide Kentucky price of corn and soybeans, acreage, and fertilizer costs were gathered from the Kentucky Crop Reporting Service. Fertilizer prices for corn and soybeans were calculated assuming that nitrogen, phosphorus, and potash were applied in a 2:1:1 ratio for corn and a 0:1:1 ratio for soybeans. The respective ratios were used as weights to form the fertilizer prices. The data on acreage were acres harvested rather than acres planted, because a consistent series on acres planted was unavailable. Data on all variables used to measure the government program came from the U.S. Department of Agriculture. Crop prices were in dollars per bushel and fertilizer prices were in dollars per ton. All data were on an annual basis.

Results

As stated earlier, numerous variable definitions for the government program for corn were attempted. The price support, the set-aside payment, and the target rate were used to measure the government program. However, the minimum diversion required to qualify for the price support payment (in percentage terms) was found to perform the best for areas 1 through 8; and the maximum diversion allowed under the price support program (in percentage terms) was found to perform the best for areas 9 through 14. Producers in the less productive areas of Kentucky seem to be more concerned with how much acreage they can divert. This is probably caused by the fact that there are many more part-time farmers in the less productive areas.

Equation (1) was estimated using the seemingly unrelated regressions (SUR) model for each of the areas. This method was used because it was felt that error terms between area equations could be correlated because of omitted variables or other reasons. The SUR provides estimates of parameters which are asymptotically more efficient than ordinary least squares by using the correlation between contemporaneous disturbances of the area equations. All functional forms were linear.

Table 1 shows the coefficient estimates, standard errors, mean elasticities, and R^2 values of equation (1) for the fourteen areas. The R^2 values were obtained using ordinary least squares. The coefficient for the relative price of corn was significantly different from zero in five of the fourteen equations. The elasticity of corn acreage with respect to the relative price of corn ranged from .34 to .56 in the short run and from .93 to 2.07 in the long run.[2] These elasticity estimates are much larger than Whittaker and Bancroft's elasticity estimates of .22 for the entire United States. However, their model used the price of corn rather than the relative price of corn, which was used in this model. Also, Kentucky can easily turn some land used for pasture into cropland if crop prices are favorable. This is not generally true of states such as Iowa and Illinois; therefore, one would expect a larger elasticity for areas in Kentucky.

The coefficient for the relative price of soybeans was significantly different from zero in five of the fourteen area equations. The cross-price elasticity ranged from −.54 to −1.00 in the short run and from −1.78 to −4.17 in the long run for these five areas.

The coefficient for the variable used to measure the government program for corn, the minimum diversion required to qualify for the price support program in areas 1 through 8 and the maximum allowed under the price support program in areas 9 through 14, was significant at the 5% level for all areas. The short-run elasticity for the government program varied from −.08 to −.26. The coefficient for lagged corn acreage was also significant at the 5% level for all areas. This coefficient varied from .37 to .76, which implies that it takes from 1.6 to 4.2 years for Kentucky farmers to adjust completely to changes in the other independent variables.

Table 2 shows the results of the corn acreage supply function when statewide data is used. Ordinary least squares was used to arrive at these estimates. The aggregated results for corn acreage are rather poor. The own-price coefficient is negative and nonsignificant. This contrasts with the consistently positive sign on the own-price coefficient for the area equations. The sign of the coefficient for the relative price of soybeans in the corn equation has the expected negative sign, but it is not significantly different from zero at the 5% level. The cross-price elasticity in the corn equation is also fairly low, −.21. The coefficient on lagged corn acreage and the government program are both significant and of the expected sign. However, the explanatory power of the statewide model, as measured by R^2, is about as high as the individual area models. This suggests that multicollinearity could be more of a problem in the statewide model.

Covariance analysis was used to test whether the area corn acreage equations could be aggregated. Covariance analysis is used to test whether a model varies between classes (or areas for this study). Given a general specification, covariance analysis

[1] Area prices were available from 1964–79 only. For earlier years these prices were extrapolated by using predicted values from a simple linear regression of respective area prices and the average price for the entire state. This procedure should be reliable because crop prices were relatively stable during the 1960–64 period.

[2] Long-run elasticities were calculated by dividing each elasticity by the adjustment coefficient (derived from the lagged acreage variable).

Table 1. Corn Acreage Supply Functions by Area

		PC_{t-1}	PS_{t-1}	AC_{t-1}	GP_t^b	R^2
Area 1	Coefficient	3,613	−2,534*[a]	0.52**	−249.9**	.71
	Standard error	(3,021)	(1,065)	(0.15)	(71.7)	
	mean elasticity	.50	−.82	.53	−.26	
Area 2	Coefficient	2,248	−1,198	0.55**	−152.8*	.57
	standard error	(1,992)	(934)	(0.13)	(63.9)	
	mean elasticity	.22	−.26	.55	−.11	
Area 3	Coefficient	7,570**	−1,921	0.73**	−154.3*	.80
	standard error	(2,571)	(1,176)	(0.11)	(68.9)	
	mean elasticity	.56	−.32	.73	−.08	
Area 4	Coefficient	−519	−683	0.42**	−191.0**	.87
	standard error	(748)	(393)	(0.07)	(35.2)	
	mean elasticity	−.06	−.19	.42	−.16	
Area 5	Coefficient	−1,262	703	0.41*	−128.3*	.78
	standard error	(1,028)	(444)	(0.14)	(45.6)	
	mean elasticity	−.20	.23	.42	−.14	
Area 6	Coefficient	88	−14	0.56**	−30.8*	.67
	standard error	(341)	(149)	(0.14)	(13.0)	
	mean elasticity	.03	−.01	.56	−.08	
Area 7	Coefficient	377**	−256**	0.60**	−21.2	.76
	standard error	(127)	(79)	(0.06)	(7.2)	
	mean elasticity	.37	−.57	.60	−.14	
Area 8	Coefficient	178	−1	0.37**	−35.4	.79
	standard error	(191)	(86)	(0.08)	(9.7)	
	mean elasticity	.07	−.00	.39	−.09	
Area 9	Coefficient	260	−239	0.48**	−15.5**	.47
	standard error	(240)	(134)	(0.08)	(5.0)	
	mean elasticity	.12	−.26	.48	−.10	
Area 10	Coefficient	410	−661	0.61**	−39.4**	.73
	standard error	(610)	(326)	(0.09)	(11.3)	
	mean elasticity	.09	−.34	.61	−.12	
Area 11	Coefficient	368*	−261*	0.74**	−9.8*	.85
	standard error	(171)	(104)	(0.05)	(4.0)	
	mean elasticity	.34	−.54	.75	−.13	
Area 12	Coefficient	224*	−231**	0.76**	−9.8**	.91
	standard error	(97)	(59)	(0.04)	(2.2)	
	mean elasticity	.41	−1.00	.77	−.25	
Area 13	Coefficient	196	−218	0.52**	−18.4**	.59
	standard error	(245)	(152)	(0.08)	(5.9)	
	mean elasticity	.09	−.23	.54	−.11	
Area 14	Coefficient	359**	−241**	0.75**	−6.8**	.96
	standard error	(98)	(60)	(0.03)	(2.1)	
	mean elasticity	.44	−.67	.75	−.12	

[a] One asterisk implies significance at the 5% level; two, at the 1% level.
[b] For areas 1–8, GP_t is the minimum diversion required to qualify for the price support program. For areas 9–14, GP_t is the maximum diversion allowed under the price support program.

tests whether the intercepts differ by class (area) and whether the slopes differ by class (area). This analysis was performed on the model specified in equation (1) to test whether the slopes and/or intercepts for the corn acreage supply function vary between areas. The tests for equality of slopes and intercepts were performed by fitting the equations to data with the coefficients constrained to be equal. The results of the constrained regression models are not reported, but are available from the authors upon request.

When acreage equations are constrained such that the slope coefficients are equal (intercepts by area are allowed to differ), the results are similar to the area results. All slope coefficients are of the expected sign and significant at the 1% level. However, the test of the hypothesis that the area slope coefficients are equal is rejected at the 1% level.

Table 2. Corn Acreage Response Functions Using Statewide Data

Dependent Variable		PC_{t-1}	PS_{t-1}	AC_{t-1}	GP_t^a	R^2
AC_t	Coefficient	−414	−5,591	.32*[b]	−1,361**	.82
	standard error	(7,963)	(3,482)	(.14)	(284)	
	mean elasticity	−.01	−.21	.31	−.15	

[a] GP_t is the minimum diversion required to qualify for the price support program for corn.
[b] One asterisk implies significance at the 5% level; two, at the 1% level.

The hypothesis that area intercepts are equal is also rejected at the 1% level.[3]

Summary and Conclusions

This paper continues the trend toward the use of more disaggregated models of acreage supply. The results of this study show that breaking down data to the substate level can improve significantly corn acreage supply analysis. The area equations were far superior to the statewide analysis. Most area equations had the expected signs for the coefficients. This was not true for the statewide results. The result that both slopes and intercepts vary between areas indicates that some aspects of corn acreage supply differ between areas. This difference between areas could be due to different production functions, adjustment parameters, or producer reactions to price changes.

This improvement using substate data is not only obtained by allowing areas to have different intercepts and slopes, but also by using the seemingly unrelated regression model. If some explanatory variable is missing from the specification, the SUR technique may account for some variation in the missing variable; thereby yielding estimates which are more asymptotically efficient.

The results of this study lend support to disaggregated acreage response models for states with diverse agriculture. However, for most major corn-producing states it is possible that such a breakdown would not improve the analysis as much as for Kentucky. Therefore, it is unknown whether such a breakdown would be worth the added cost of data collection and analysis for other states.

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[3] A covariance analysis was also applied to the log-linear models for corn. The hypothesis tested, in this case, is that the elasticities were the same for each area. This hypothesis was rejected at the 1% level.

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A Preliminary Evaluation of Price Forecasting Performance by Agricultural Economists

James C. Cornelius, John E. Ikerd, and A. Gene Nelson

The purpose of this note is to review the results of past AAEA-sponsored commodity outlook surveys and to evaluate forecasting accuracy and performance. We discuss the methodology for conducting such a review and suggest some factors that seem to affect the accuracy of responses. How does the span of the forecast affect accuracy? Is it easier to forecast prices for some commodities than others? Are some forecasters more accurate than others?

Background and Survey Procedure

The Survey of Annual Outlook Information is the result of an initiative begun by the AAEA Agricultural Statistics Committee in 1977. A committee task force proposed the survey and an outlook symposium as part of annual AAEA meetings and outlined procedures which have since been followed.

Survey forms are mailed to selected AAEA members in early summer with the request that completed forms be returned two to four weeks before the annual meeting to insure timely information. Various lists of agricultural economists, including regional extension committees, industry outlook groups, USDA outlook staff, and previous survey participants, are used.

No attempt is made to obtain a random sample of the AAEA membership nor to obtain a statistically representative sample of AAEA members involved in outlook work. So, it is not possible to draw conclusions concerning outlook opinions of the AAEA in general from this survey. The primary purpose has been to provide stimulus for discussion of agricultural outlook at the annual meeting.

The survey questionnaire asks for outlook forecasts of production, disappearance, and prices for specified agricultural commodities and indices of agricultural income, land value, and general price levels. Respondents are asked to provide forecasts for only those items about which they feel professionally competent. The outlook forecasts are made for two periods: the current year and the next year. For example, in June of 1978, forecasts were made for 1978 and 1979. This format has led to some misunderstanding by respondents, especially concerning wheat, because the designated crop year does not correspond to the calendar year.

Survey Response

There were fifty-three responses to the survey questionnaire in 1978, including thirty-six university economists, eleven from industry and business, and six from government agencies. Of the fifty-three, twenty indicated that forecasting was a major responsibility in their position. There were seventy-four respondents to the 1979 survey, fifty from universities, thirteen from industry and business, and eleven from government agencies. Twenty-five of these respondents had major forecasting responsibilities.

The AAEA outlook surveys in 1978 and 1979 have been summarized (Ikerd) and briefly reviewed (Futrell) as a first step in evaluating the survey results. A 1980 survey also was undertaken but the results have not yet been evaluated. The following section is a more detailed assessment of the 1978 and 1979 surveys. It is designed to demonstrate methodology for evaluating the outlook survey results and the survey procedure.

Procedure for Analysis

Individual responses were coded to allow for adding new respondents in succeeding years and additional data for past respondents. The consistency of response varied among individuals. Most made point estimates, but others specified a range. When a range was given, the high and low of the range were averaged into a point estimate.

Interpretation of Results

The distributions illustrated in figure 1 present a graphic review of respondents' forecasting performance. Only two representative price forecasts from the survey are illustrated here—slaughter cattle and soybeans. Each forecast is identified by the year of the forecast followed by the year for which the forecast was made. Thus, 78/79 is a forecast made in 1978 for the year 1979. The selection of

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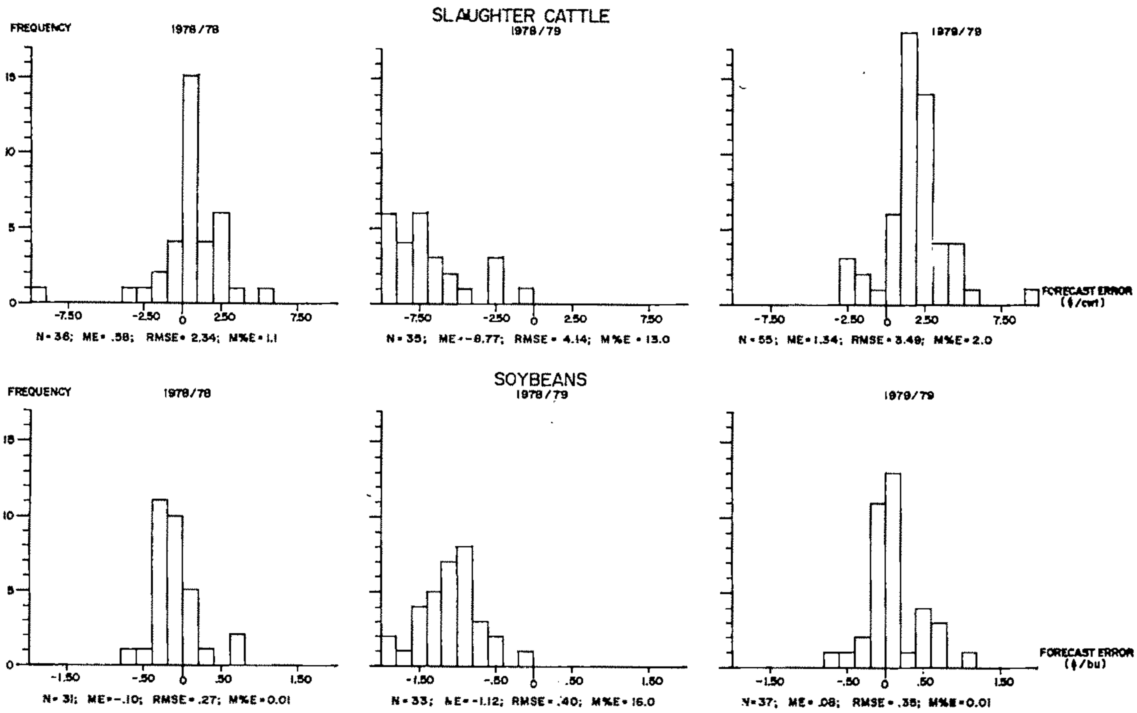

Figure 1. Distribution of price forecast error

distribution intervals for the price prediction error was subjective, based on the observed ranges of the errors.

In addition to the distribution of forecast errors, additional evaluation statistics are listed beneath each graph. These include: *N*, number of respondents; *ME*, mean forecast error; *RMSE*, root mean-squared error; and *M%E*, mean percent error. Intercommodity comparisons for five major commodities including slaughter cattle and soybeans are shown in table 1.

Depending upon one's objectives, it might be appropriate to compute other evaluation statistics if the data base is expanded. These might include tracking measures such as indices of forecast error over and under actual values, error decompositions, and cyclical or dynamic properties of the responses (Dhrymes, P. et al., Mincer and Zarnowitz, Granger).

Preliminary Findings

A few tentative conclusions can be drawn about the three questions. How does the span of the forecast affect accuracy? Is it easier to forecast prices for some commodities than others? Are some forecasters more accurate than others?

The difference in accuracy associated with the span of the forecast can be evaluated by comparing

Table 1. Mean Percentage Price Forecast Error and Root Mean-Squared Error, Selected Agricultural Commodities, AAEA Outlook Survey, 1978 and 1979

		Period					
		1978/78		1978/79		1979/80	
Commodity	Forecast Unit	M%E	RMSE	M%E	RMSE	M%E	RMSE
		(%)	($/unit)	(%)	($/unit)	(%)	($/unit)
Choice Slaughter Steers	$/cwt	1.1	2.34	13.0	4.14	2.0	3.49
Choice Feeder Steers[a]	$/cwt					3.0	5.67
Barrows & Gilts	$/cwt	3.2	2.34	4.7	3.73	0.8	1.68
Corn	$/bu	6.0	.14	12.0	.15	2.0	.09
Soybeans	$/bu	0.01	.27	16.0	.40	0.01	.35

[a] Feeder cattle were not included in the 1978 outlook survey.

the estimates made in 1978 for the 1979 year with the estimates made in 1979 for the 1979 year. For selected commodity price forecasts (cattle, hogs, corn, and soybeans), the 1979 estimates were more efficient measured by either the mean percentage error or the root mean-squared error (table 1). This is to be expected since some monthly price data were already reported for the current year at the time the forecasts were made. There is more information available for short-run, as compared to long-run, forecasts.

A second generalization is that forecast accuracy varies among commodities. For example, for current years, soybean price forecasts have been much more accurate than corn in terms of the mean percentage error (table 1). For the livestock commodities, it appears that hog prices are easier to forecast than cattle prices. However, these data represent a very limited sample. The distribution of random error among the commodities may be unequal, and a longer time series of data would permit more accurate intercommodity forecast error comparisons.

Even with only two years' data, there is the intriguing opportunity to compare the performance of individual forecasters who responded to both surveys. For example, consider the seventeen respondents who forecast current year slaughter cattle price in both 1978 and 1979. Performance statistics can be calculated to evaluate their "track records" of accuracy. Nine of the seventeen forecasters had relatively good track records. The others exhibited a declining degree of accuracy, at least during the two years sampled. The potential for using these results to improve forecasting performance may be limited because the present survey format pledges anonymity of the respondents.

Issues for Further Study

Preliminary comparisons of survey results—among commodities, among forecast spans, and among forecasters—point to some challenging issues in forecasting accuracy. For example:

(*a*) Why can the prices of some commodities be forecast with geater accuracy than others? What can be done to improve the accuracy of these others?

(*b*) For what forecast span (one month, one quarter, one year, two years, etc.) can forecasts be made accurately? Does the length of this span vary with the commodity involved?

(*c*) Why are some forecasters more accurate than others? How can those with poorer performances improve their accuracy?

The limitations inherent in drawing conclusions regarding forecasting performance for a two-year data series must be recognized. However, these results do suggest hypotheses, and indicate the potential for continuing to expand this survey. An expanded data base will allow more thorough evaluations of price-forecasting performance.

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Simplified Measurement of Consumer Welfare Change

Dennis C. Cory, Russell L. Gum, William E. Martin, and Ray F. Brokken

Various measures of consumer welfare change have been proposed in the literature, each claiming relative superiority in accurately reflecting the income equivalent of a welfare change. Selection of an appropriate measure in empirical research is complicated by both theoretical and estimation considerations. Compensating variation (CV) and equivalent variation (EV) as measures of consumer welfare change normally are preferred theoretically since they indicate whether or not a policy change is a potential Pareto improvement. However, use of Paasche Variation (PV), Laspeyres Variation (LV), or consumers' surplus (CS) measures is desirable empirically since less information is required for calculation. While Hicks long ago (1943) suggested that the distinctions among these measures would be of little empirical significance in applied studies, other recent authors, including Mishan, have insisted on the necessity for theoretical precision.

Willig established the usefulness of CS as an approximation to CV and EV measures of consumer welfare change under specified conditions. However, conditions under which PV and LV can be useful have not been rigorously developed. In this paper, guidelines are developed for using PV and LV as empirical approximations for theoretically preferable CV and EV measures. These guidelines require less information than those developed by Willig and PV and LV measures have several additional advantages in applied research.

Alternative Measures of Consumer Welfare Change

The relationships among the CV, EV, PV, LV, and CS measures of consumer welfare change are illustrated in figure 1 for a single price decline.

Compensating variation is the amount of compensation, paid or received, that will leave the consumer in the initial welfare position (U_0) following the change in price if any quantity of the commodity can be bought at the new price. Consider a consumer with income Y_0 initially in equilibrium at point A. Income of BB_1 could be forgone while allowing reestablishment of equilibrium at point C with no change in utility. In this example, BB_1 is the compensating variation measure of the consumer welfare change. This value corresponds to the area P_0IFP_1 in price-commodity space bounded by the original and new price lines and the compensated demand curve D_C.

Equivalent variation is the amount of compensation, paid or received, that will leave the consumer in the subsequent welfare position (U_1) in the absence of a price change if any quantity of the commodity can be bought at the old price. For the consumer initially in equilibrium at A, an income increment of AA_1 would be required to achieve the utility level equilibrium at the lower price (point B) should the initial price levels prevail (point D). In this case, AA_1 is the equivalent variation measure of the change in consumer welfare. This value corresponds to the area P_0GKP_1 bounded by the price lines and the compensated demand curve D_E.[1]

The consumer's surplus change in this example is given by P_0IKP_1, the area bounded by the price lines and the ordinary Marshallian demand curve D_m. Comparing these measures for the case of a single price decline yields the familiar relationship, $CV < CS < EV$. The inequalities reverse for a price increase.

Laspeyres variation is the exact change in income required to allow the purchase of the original quantities of all goods after prices have changed. Paasche variation, on the other hand, is the exact change in income required to allow the purchase of the subsequent set of goods when facing the initial price situation. For the case of a single price fall in figure 1, LV would equal AA_2 while PV would equal BB_2, bounding the CV, CS, and EV measures of consumer welfare change. In price-commodity space, LV is given by P_0IHP_1, and PV is given by P_0JKP_1. Comparing all five measures of consumer welfare change for a price decline illustrates that

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[1] Some analysts feel that a more operational definition for compensating variation is "the amount of income which must be taken away from a consumer (possibly negative) after a price and/or income change to restore him to his original welfare level." This definition results in a measure that is positive for a price fall and negative for a price rise. If one is interested in performing compensation tests and adding up gains and losses over various groups, it is essential that compensating variation for price rise have a different sign from the compensating variation for a price fall. An analogous definition is made for equivalent variation.

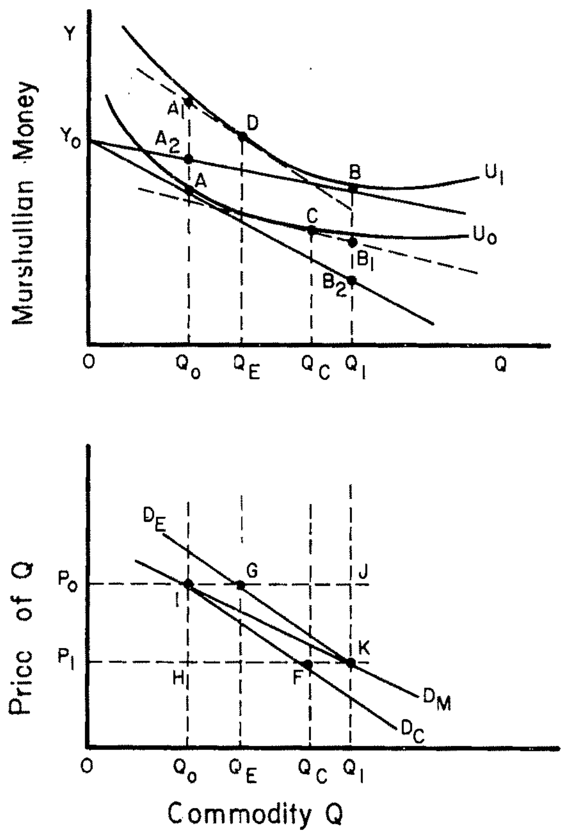

Figure 1. Compensating, equivalent, Paasche, and Laspeyres variations for the case of a price decline

$LV < CV < CS < EV < PV$. That is, LV and PV bound CV, CS, and EV. On the other hand, LV and CS bound CV, and PV and CS bound EV. All inequalities reverse in the case of a price increase.[2]

The desirability of using CV or EV as a measure of consumer welfare change is well established in the theoretical literature whenever post-policy quantity adjustments are possible. Yet, CS, LV, and PV can be easily calculated in empirical studies. In the following section alternative approximations for CV and EV using CS, LV, and PV are discussed.

Approximations for Compensating and Equivalent Variation Measures

Willig established the validity of the following rules of thumb for a single price change; if $|\bar{\eta}A/2m^o| \le .05$, $|\underline{\eta}A/2m^o| \le .05$, and if $|A/m^o| \le .9$, then

$$(1) \qquad \frac{\underline{\eta}|A|}{2m^o} \le \frac{CV-A}{|A|} \le \frac{\underline{\eta}|A|}{2m^o}, \text{ and}$$

$$(2) \qquad \frac{\underline{\eta}|A|}{2m^o} \le \frac{A-EV}{|A|} \le \frac{\bar{\eta}|A|}{2m^o},$$

where A is consumer's surplus area under the demand curve and between the two prices, CV is compensating variation corresponding to the price change, EV is equivalent variation corresponding to the price change, m^o is consumer's base income, and $\bar{\eta}$ and $\underline{\eta}$ are, respectively, the largest and smallest values of the income elasticity of demand in the region under consideration. Notice that while these formulas place observable bounds on the percentage errors made by approximating CV or EV with the observable CS, consumer income and income elasticity data are required to make the rules operational.

Using the bounding properties of PV and LV, additional rules of thumb can be derived which (a) place observable bounds on the percentage error of approximating CV with either CS or LV (b) place observable bounds on the percentage error of approximating EV with either CS or PV, (c) require no information about consumer income or income elasticities, and (d) establish conditions under which the easily understood PV and LV measures of welfare change can be reported to policy makers.

Assuming that the demand curve is linear over the range under consideration, it follows that

$$(3) \quad \frac{CS-LV}{|CS|} \le \lambda \text{ when } |\Delta Q| \le \frac{2\lambda}{(1-\lambda)} Q_o, \text{ and}$$

$$(4) \quad \frac{PV-CS}{CS} \le \lambda \text{ when } |\Delta Q| \le \frac{2\lambda}{(1-\lambda)} Q_o,$$

where CS, LV, PV are defined as before, λ is a specified percentage of error, ΔQ is change in quantity demanded resulting from the price change, and Q_o is original quantity demanded. Refer to figure 1. Equation (3) is derived as follows. As the price falls from P_o to P_1, the consumer is assumed to move along the linear Marshallian demand curve D_M, increasing quantity demanded from Q_o to Q_1. Let $\alpha = P_oIHP_1$ and $\beta = IHK$, then $\frac{CS-LV}{|CS|} = \frac{\beta}{\alpha+\beta}$. Thus, $\frac{CS-LV}{|CS|} \le \lambda$ implies that $\frac{\beta}{\alpha+\beta} \le \lambda$ so that $\beta \le [\lambda/(1-\lambda)]\alpha$. This expression can be rewritten as $\frac{1}{2}\Delta P \cdot \Delta Q \le [\lambda/(1-\lambda)]\Delta P \cdot Q_o$ from which it follows that $\Delta Q \le [2\lambda/(1-\lambda)]Q_o$. The derivation is similar for (4).

An example can illustrate the usefulness of (3) and (4). If a value of .05 is selected for λ, then LV and PV will be within 5% of CS whenever the change in quantity demanded is less than 10% of the original quantity demanded. Since LV and CS bound CV (and PV and CS bound EV) for a single price decline, it follows that whenever $\Delta Q \le 10Q_o$, CS and LV are within 5% of CV. Moreover, CS and PV are within 5% of EV. That is, LV and PV can be used unapologetically for CV and EV, respectively,

[2] Paasche and Laspeyres variations were discussed by Hicks in 1942. These measures acquired their names by analogy to Paasche and Laspeyres indexes, but are, in fact, much simpler computations. For a discussion of the development of CV, EV and CS, see Currie, Murphy, and Schmitz.

in all cases where quantity demanded changes by less than 10% of the original quantity demanded.[3]

In general, knowing the quantity change which results from a price change, use of (3) and (4) allows an easily calculated upper bound on the associated percentage error which might result from using PV, LV or CS approximations to CV and EV. Moreover, this calculation only requires price and quantity change information and not income and income elasticity information as required by Willig's formulas shown in (1) and (2). Finally, for policy makers willing to accept a percentage estimation error of λ, these rules provide criteria against which the acceptability of PV and LV approximations of CV and EV can be evaluated. PV and LV are particularly useful approximations when the associated estimation error is acceptable, since both measures have clear intuitive interpretations, overcoming objections of Cochrane and others who argue that CV, EV, and CS measures of consumer welfare change are incomprehensible to policy makers.

Implications for Applied Research

These results suggest a pragmatic approach to applied policy analysis. First, the Paasche and Laspeyres measures of welfare change should be calculated. This quick and inexpensive computation provides a range in which the actual value of the consumer welfare change will lie. Next, assuming a direct linear path of price-quantity adjustment, the midpoint of this range is the estimate for the change in CS. In many policy contexts, this simple two-step procedure will provide adequate information for rigorous decision making.[4]

In short, PV and LV measures of consumer welfare change provide policy analysts with a simple, useful, and theoretically coherent evaluation tool. Careful utilization of these analytic tools in applied benefit-cost studies could be productively employed much more frequently.

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[4] For an application of this simple method in an agricultural policy context, see Cory, Gum, Martin, and Leigh.

Optimal Choices among Alternative Technologies with Stochastic Yield

Joseph Yassour, David Zilberman, and Gordon C. Rausser

Often, farmers have to choose among discrete alternatives with uncertain outcomes. This occurs, for example, when farmers consider adoption of new technologies, such as new farm machinery or irrigation systems. Understanding the process of technological adoption requires the explicit recognition of uncertainty and risk aversion. The purpose of this paper is to advance a new approach for investigating this process. It will be demonstrated that this approach is, in many respects, superior to current approaches.

Current Approaches

Expected utility is the major approach employed in analyzing farmers' behavior under uncertainty. Since its introduction by von Neumann and Morgenstern, it has been refined and extended to explain the behavior of economic agents. Sandmo has introduced a general model which requires neither the specification of the utility function nor the distribution of the random variable. It assumes multiplicative risk and is limited to problems with only one random variable. Sandmo's model has been modified by Feder to analyze the adoption of new technologies in less developed countries. While these theoretical models are interesting and insightful, their empirical weakness lies in their theoretical strength. They are too general. Quantitative analysis requires more detailed specifications.

Another method of risk analysis consistent with expected utility is stochastic dominance (Anderson). While these rules have the advantage of not requiring knowledge of utility functions, their practical use is restricted to comparison of discrete alternatives; and they are often inconclusive.

When the distribution of the random variable is described by only two parameters or the utility function is quadratic, Tobin has demonstrated that the expected utility can be introduced as a function of the mean and the variance. The behavior of farmers under uncertainty is studied frequently using the mean-variance (E-V) analysis assuming that farmers maximize a linear combination of the mean and the variance (Freund, Pope and Just). This corresponds to maximization of expected utility of income when either the utility function is quadratic or the random variable is normally distributed and the measure of absolute risk aversion is constant. These assumptions are quite restrictive. Quadratic utility is unacceptable for theoretical reasons because it implies increasing absolute risk aversion (Arrow, Pratt). On the other hand, many natural phenomena are described by probability distributions that are not normal. For example, Day has shown that crop yields can be best represented by the Gamma distribution. Moreover, the Gamma distribution was found to be accurate in representing precipitation and drought occurrence (Starr, Rudman, Whipple). Thus, the use of the convenient linear E-V framework in these cases corresponds to the imposition of a quadratic utility function with all of its associated limitations.

New Approach

A new framework, which is equally convenient and includes as a special case the linear mean-variance analysis, will be referred to as the exponential utility, moment-generating function approach (EUMGF). This approach assumes an exponential utility function which implies constant absolute risk aversion rather than increasing absolute risk aversion (Arrow, Pratt). This utility function can be applied conveniently in conjunction with all distributions which have moment-generating functions. Moreoever, under certain criteria, technology choices made by the EUMGF approach are applicable for decision makers with decreasing absolute risk aversion.

The Model

Suppose a farmer must decide whether to continue employing his existing technology, T_0, or to adopt a new technology, T_1. Each technology is presumed to have deterministic variable costs of c_0 and c_1 and stochastic yields, Y_0 and Y_1, respectively. The net profit under technology, i, is the random variable, R_i,

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$$R_i = PY_i - c_i, \tag{1}$$

where $i = 0, 1$, and P is the fixed output price.

Given the above specifications, the new technology will be adopted if

$$E_1\, U(R_i) > E_0\, U(R_0), \tag{2}$$

where U is the utility function and E_i is the expectation operator for the yield distribution of the ith technology. The EUMGF approach assumes exponential utility function, i.e.,

$$U(R) = -e^{-rR}, \tag{3}$$

where r is the measure of absolute risk aversion. Substituting equations (3) and (1) into equation (2) provides the basis for introducing the moment-generating function and, thus, obtains a compact analytical solution. That is,

$$E_1\, [-e^{-r(Y_1P-c_1)}] > E_0\, [-e^{-r(Y_0P-c_0)}]\ , \tag{4}$$

which is equivalent to

$$e^{rc_1}\, M_1(-rP) < e^{rc_0}\, M_0(-rP), \tag{5}$$

where

$$M(t) = E\, e^{tY} \tag{6}$$

is the moment-generating function of the yield-probability distribution.

The Case of Normal Yield Distributions

When the distribution of yields under both technologies is normal, the EUMGF reduces to the linear E-V framework. The moment-generating function of the normal distribution is

$$M(t) = \exp\left(\mu t + \sigma^2 \frac{t^2}{2}\right), \tag{7}$$

where μ and σ are the mean and standard deviation. Substituting equation (7) into equation (5), taking natural logarithm and simplifying the outcome, we have

$$P[(\mu_1 - \mu_0) - (c_1 - c_0)] - \left[\frac{r}{2} P^2(\sigma_1^2 - \sigma_0^2)\right] > 0. \tag{8}$$

As equation (8) suggests, the new technology will be adopted if the increase in the expected profit exceeds the increase in the variance times half the risk-aversion measure. This condition is obtained also when the objective is to maximize the expected profit less $r/2$ times the variance, i.e., $E - (r/2)\ V$.

Since expected profit is measured in monetary terms, the above results indicate that for the EUMGF approach,

$$CE_n(T_i) = P\mu_i - \frac{r}{2} P^2\sigma_i \tag{9}$$

is the certainty equivalent of profit under the ith technology when the yield is normally distributed. The risk premium is $(r/2)P^2\sigma_i^2$, where $r/2$ is the price per dollar of variance (r is also the measure of constant absolute risk aversion, i.e., $r = -U''/U'$). Condition (8) ensures that the technology with the higher certainty equivalent is chosen.

The Case of Gamma Yield Distributions

As indicated above, there is sufficient evidence to indicate that yields are better approximated by skewed distributions such as gamma. The density function for the gamma distribution is

$$f(Y) = \frac{\lambda^\alpha}{\Gamma(\alpha)}\, Y^{\alpha-1}\, e^{-\lambda Y}, \tag{10}$$

where $Y > 0, \Gamma(\alpha)$ is the complete gamma function, and α and λ are the parameters of the distribution. The moment-generating function of the gamma distribution is

$$M(t) = \frac{1}{(1 - t/\lambda)^\alpha}. \tag{11}$$

Substituting equation (11) into equation (5) and taking the logarithms of both sides yields a condition (stated in monetary units) for the adoption of the new technology,

$$\frac{\alpha_1 \ln(1 + rP/\lambda_1)}{r} - c_1 > \frac{\alpha_0 \ln(1 + rP/\lambda_0)}{r} - c_0. \tag{12}$$

The expressions on both sides of equation (12) are the certainty equivalents of profits under a specific technology. Since the mean of gamma distribution is α/λ and the variance is α/λ^2, the certainty equivalent of the ith technology for the gamma distribution can be derived from equation (12), i.e.,

$$CE_Y\,(T_i) = \frac{1}{r}\left(\frac{\sigma_i}{\mu_i}\right)^2\ \ln\left(1 + \frac{\sigma_i^2}{\mu_i} rP\right) - c_i; \tag{13}$$

and the condition for adoption of the new technologies can be expressed in terms of the respective mean and variance of yields, i.e.,

$$\frac{1}{r}\cdot\left(\frac{\mu_1}{\sigma_1}\right)^2 \ln\left(1 + \frac{\sigma_1^2}{\mu_1} rP\right) - c_1 > \frac{1}{r}\left(\frac{\mu_0}{\sigma_0}\right)^2 \ln\left(1 + \frac{\sigma_0^2}{\mu_0} rP\right) - c_0. \tag{14}$$

Special Cases of Gamma Yield Distributions

The decision rule for the choice of technology becomes much simpler for two special cases of the gamma distribution, namely, the chi-squared and

exponential distributions. When the parameters of the gamma distribution are $\alpha = N/2$ and $\lambda = 1/2$, the distribution becomes chi-squared with N degrees of freedom. Introducing these results into equation (12) and noting that the mean of a chi-squared distribution is its degrees of freedom ($N = \mu$), the rule for selecting the modern technology when both technologies have a chi-squared yield distribution is

$$(15) \qquad \mu_1 - \mu_0 > 2r \frac{(c_1 - c_0)}{\ln (1 + 2rP)}.$$

When the mean of a gamma distribution is equal to its standard error, the distribution becomes exponential. Introducing $\mu_i = \sigma_i$ into equation (14) and rearranging the terms, the rule for the selection of the modern technology when the yields are exponentially distributed is

$$(16) \qquad \ln \frac{1 + r\mu_1 P}{1 + r\mu_0 P} > c_1 - c_0.$$

Comparison of Normal and Gamma Yield Distributions

To understand how different specifications of the yield distribution affect the choice of technology, consider two yields with the same mean and variance but with different distribution. Using a Taylor expansion of the logarithmic function and assuming $(\sigma^2/\mu)rP < 1$, the CE of the gamma distribution in equation (13) becomes

$$(17) \quad CE_\gamma(T) = \frac{1}{r}\left(\frac{\mu}{\sigma}\right)^2 \sum_{j=1}^{\infty} (-1)^{j-1} \frac{1}{j}\left(\frac{\sigma^2}{\mu} rP\right)^j - c,$$

where j is the index.

Subtracting equation (9) from equation (17) yields the difference between the CEs of the gamma and normal distributions:

$$(18) \quad CE_\gamma(T) - CE_n(T) = \frac{1}{r}\left(\frac{\mu}{\sigma}\right)^2 \sum_{j=3}^{\infty} (-1)^{j-1} \frac{1}{j}\left(\frac{\sigma^2}{\mu} rP\right)^j.$$

Assuming that all elements from $j = 4$ on are insignificant, expression (18) reduces to

$$(19) \quad CE_\gamma(T) - CE_n(T) \approx \frac{1}{3} \frac{\sigma^4 r^2 p^3}{\mu} > 0.$$

It is clear from equation (19) that a random yield with gamma distribution is preferred to that with normal distribution if both have the same mean and variance and equal production cost. This result clarifies the limitations of the frequently assumed normal distribution for decision-making purposes in cases where the actual distribution is skewed. As shown in equation (19), this misspecification leads to underestimation of the benefit from the random yield and may also result in erroneous decision making. In particular, if a linear E-V framework is employed assuming incorrectly that yields are normally distributed when, in fact, they are gamma distributed, the resulting choices are generally too conservative.

The importance of the above result will be illustrated by a simple example and by an empirical example. For the simple illustration, suppose the existing technology has mean, μ, and standard deviation, σ; and a new technology is introduced with the same production cost and a random yield which is an indefinite number, k, times the existing technology yield. Using equations (9) and (13), the CEs of the new technology under both the normal and gamma distributions are

$$(20) \quad CE_n\,(T_k) = k\left(P\mu - \frac{k}{2} rP^2\,\sigma^2\right) - c,$$

$$(21) \quad CE_\gamma\,(T_k) = \frac{1}{r}\left(\frac{\mu}{\sigma}\right)^2 \ln\left(1 + \frac{k\sigma^2}{\mu} rP\right) - c.$$

These two CEs are depicted as functions of k, the technology multiplier, in figure 1.

The CE for the gamma distribution is always higher than that of the normal distribution and increases at a decreasing rate with k. The CE for the normal distribution rises for relatively small k's, peaks at $k = \mu/\sigma^2 rP$, and decreases thereafter. Thus, technologies with higher multipliers are always preferred under the gamma distribution. However, they will not be preferred if the yield distribution is assumed to be normal. In figure 1, for example, T_1 is inferior to T_{k_1} for the gamma distribution but is superior for the normal distribution.

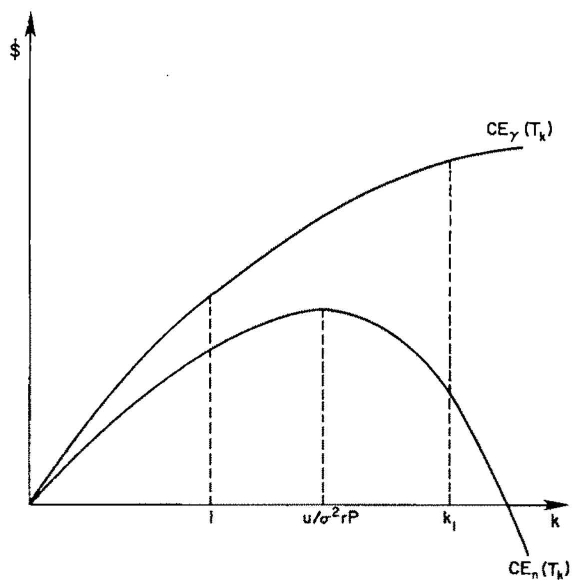

Figure 1. Certainty equivalents under gamma and normal yield distributions

The importance of using the right specification increases with the measure of risk aversion. From equations (9) and (13) it can be derived that both *CE*s decrease with r, but the *CE* under the normality assumption decreases more rapidly. Thus, the difference between the two *CE*s increases with the degree of risk aversion. The above results have another implication—assuming a normal distribution of yield will result in underestimation of the Arrow-Pratt measure of risk aversion if, in fact, the real distribution is skewed.

Turning to the empirical example, we employ data reported by Roumasset concerning production technologies available to operators of the rice land in the Philippines. Four technologies are considered. One is a traditional technology, denoted by T_0, which is lowest in yield as well as lowest in cost and risk. The other three, denoted by T_1, T_2, and T_3, are modern technologies. They use high-yield variety seeds combined with cash inputs (such as fertilizer) and require more labor. Among them, T_1 has the lowest costs and yields, while T_3 has the highest yield and also the highest cost. The means and standard deviations of the yield for the four technologies, as well as output price and production cost per acre, are given in parentheses in table 1. The table presents the certainty equivalents of profits under the four technologies for a farm with 1 hectare of land. These certainty equivalents are computed for the two yield distribution specifications (i.e., normal and gamma) under different degrees of risk aversion. The measure of absolute risk aversion varies from zero (risk neutrality) to .01. The optimal choices under both distribution specifications for each level of risk aversion are given in separate columns.

Under both specifications, increases in risk aversion result in a gradual move to less risky technologies. This tendency is much stronger under normality. For example, for the gamma distributions, all the farms with $r \leq .003$ will adopt the most modern techniques, while only the farms with $r \leq .001$ will do so under normality. The traditional technology will be adopted by all the farms with $r \geq .005$ under normality but only by the farms with $r \geq .009$ under gamma distribution. The effect of an increase in risk aversion on the certainty equivalents is much more drastic under the normal distribution, especially for the high-risk technology. Note that the certainty equivalent of the most modern technology is negative and rapidly declines for $r \geq .007$.

Other Yield Distributions

The gamma and normal yield distributions are simply illustrative of the analysis that can be conducted using the methodology developed here. Any continuous or discrete yield distribution with a well-behaved, moment-generating function can be analyzed. Moreover, in many cases, a new technology results in stochastic yield which differs from that of the existing technology not only in the parameters but in the type of the distribution. Consider, for example, a case where the yield under the existing technology, T_0, has a continuous distribution, say, chi-squared with N_0 degrees of freedom. Under the new technology, T_1, suppose the distribution of the yield can be best approximated by a Poisson distribution with parameter λ_1. The moment-generating function of the Poisson distribution is given by

$$M(t) = \exp[\lambda(e^t - 1)]. \tag{22}$$

Table 1. The Certainty Equivalent under Alternative Parameters

Risk Aversion Coefficient,	Technology								Optimal choice	
	T_1 (32, 5, 106, 16)		T_2 (70, 25, 350, 16)		T_3 (80, 30, 410, 16)		T_4 (90, 35, 490, 16)			
r	N	γ	N	γ	N	γ	N	γ	N	γ
.000	406.0	406.0	770.0	770.0	870.0	870.0	950.0	950.0	T_3	T_3
.0001	405.6	405.6	762.0	762.0	858.4	858.6	934.3	934.5	T_3	T_3
.001	402.8	402.8	690.0	696.0	743.2	757.8	793.0	812.0	T_3	T_3
.002	399.6	399.7	602.0	629.3	639.6	690.2	636.0	705.0	T_2	T_3
.003	396.4	396.6	522.0	577.0	524.0	613.0	472.0	618.0	T_2	T_3
.004	393.2	393.6	450.0	535.8	407.2	554.1	322.0	545.0	T_1	T_2
.005	390.0	390.6	362.0	491.0	294.0	502.0	166.0	484.0	T_0	T_2
.006	386.8	387.7	282.0	455.4	178.0	457.0	9.2	431.0	T_0	T_2
.007	383.6	384.8	202.0	423.0	63.0	418.0	−147.0	384.0	T_0	T_1
.008	380.4	381.9	122.0	394.0	−63.0	379.5	−304.0	343.7	T_0	T_1
.009	377.2	379.1	42.0	367.0	−178.3	348.0	−476.0	303.0	T_0	T_0
.010	374.0	376.4	−29.8	345.0	−281.0	322.0	−617.0	274.0	T_0	T_0

Source: Roumasset.

[a] Each technology is defined by μ_i, σ_i, c_i, and **P**.

Following the same procedure as above and using equations (15) and (22), it is found that the new technology is adopted if

$$\mu_1 (1 - e^{-rP}) - \mu_0 \frac{1}{2} \ln (1 + 2rP) > r(c_1 - c_0), \tag{23}$$

where $\mu_0 = \lambda'_0$ and $\mu_1 = \lambda_1$ are the expected yields for the two distributions.

Stochastic Dominance, Decreasing Absolute Risk Aversion, and the Exponential Utility, Moment-Generating Function Approach

First-order stochastic dominance (FSD) and second-order stochastic dominance (SSD) are useful approaches that can be employed for discrete technological choices. Hammond proved that, if the new technology is superior according to the FSD criterion, it will be selected by any risk-neutral or risk-averse firm. If the new technology is superior according to the SSD criterion, it will be selected by strictly risk-averse decision makers. Thus, whenever the new technology is superior according to either the FSD or SSD criterion, it will be selected according to the EUMGF which reflects strict risk-aversion behavior. The main weakness of the stochastic-dominance approach is that it may lead to inconclusive results for many choice situations. By contrast, the EUMGF approach leads to a complete ordering of uncertain profit distributions. For example, the FSD and SSD rules are inconclusive in comparing technologies with normal and gamma profit distributions and the same means and variances (Hammond). The EUMGF approach will select the gamma technology (as equation [19] indicates).

One possible criticism of the EUMGF approach is that it assumes constant absolute risk aversion and, thus, does not admit decreasing absolute risk aversion (DARA). Nevertheless, technology choices made with the EUMGF approach can be used by decision makers with DARA. In comparing modern with old technologies, we expect the modern technologies (i.e., high-yield varieties or chemical fertilizers) to have higher expected profit but less concentrated distributions than the traditional technologies would have. The probability of earning very low or very high profits with the modern technology is higher than with the old technology. Thus, it is plausible that the cumulative yield distribution of profits under the modern technology crosses that of the old technology once from above. For these properties, Hammond found that, if the modern technology is adopted under an exponential utility function, it will also be adopted under utility functions which exhibit DARA as long as the degree of risk aversion for the DARA function is smaller than the absolute risk aversion (say, r) of the former. Similarly, if the old technology is chosen under constant absolute risk aversion, it will also be adopted under DARA when the measure of risk aversion for DARA is always greater than r.

Conclusions

The use of the mean-variance approach to analyze farmers' behavior under uncertainty is often objectionable on theoretical and empirical grounds. Nevertheless, it is commonly applied because of its computability. Therefore, it is desirable to develop alternative methods for risk analysis which are both theoretically sound and easily applied.

One possible direction of research is to assume specific utility functions which are preferred to the quadratic utility function and to use existing results in mathematics and statistics to derive simple expressions for the expected utility of income under various distributions. Such an approach is introduced in this paper and is applied to discrete choices among alternative technologies with random yields. The utility of income was described by the negative exponential utility function. This allows expected utility to be expressed using the moment-generating yield function. The methodology was used to derive specific decision rules for cases where yields are gamma distributed. It showed that the E-V approach may lead to significantly inferior decisions. In general, the use of the decision rule suggested here results in the adoption of a more risky technology in some cases when the mean-variance approach erroneously recommends against its use.

The approach here is applicable to more general situations. For example, the analysis under uncertainty when both price and yield are uncertain allows analysis when total revenue distribution is not normal, even though price and yield are hypothesized to be normal. Also, the approach could easily be extended to accommodate linear combinations of random variables—e.g., revenue and cost uncertainty.

The utility function assumed here implies constant absolute risk aversion. This assumption is more reasonable than is the increasing absolute risk aversion implied by quadratic utility (and the E-V approach). However, Arrow has argued that most individuals have decreasing absolute risk aversion. Thus, even though the new method introduced here is an improvement over the mean-variance approach, economists should continue to seek utility functions with both decreasing absolute risk aversion and simple expressions for expected utility.

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Multiple Optimal Solutions in Linear Programming Models

Quirino Paris

Since 1950, empirical studies using linear programs (LP) have all neglected the consequences of one important aspect of mathematical programming. Simply stated, the polyhedral nature of the solution set in LP models may cause multiple optimal solutions if some plausible conditions are realized. If and when empirical problems possess alternate optimal solutions, why is only one of them usually selected for presentation in final reports which, often, also make efficiency judgments and prescribe sweeping policy changes?

When LP is used for analyzing empirical problems, an implicit comparison is usually made between the activities actually chosen and operated by the economic agent under scrutiny and the optimal activities suggested by the model's solution. In several instances (Wicks), the use of LP for policy planning has inspired the use of Theil's U-inequality coefficient to assess formally the discrepancy between actual and optimal (predicted) activities. Desired values of the U coefficient are those close to zero, attained when the squared distance between actual and LP optimally predicted activities is small. Implicitly, however, minimum distance criteria have been used by many authors to assess the plausibility and performance of their LP models. In the presence of multiple optimal solutions, however, the selection of a specific solution for final analysis is crucial and should not be left to computer codes as probably has been the case in all reported studies.

Furthermore, the empirical LP problem is made even more complex by the existence of quasi-optimal solutions; that is, those solutions which change the optimal value of the objective function only by a fractional percentage. Because the information used to specify empirical problems is seldom exact, quasi-optimal solutions may legitimately be considered as suitable candidates for final reporting.[1]

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[1] In a brief note, McCarl has suggested perturbation procedures and an ad hoc series of actions to avoid multiple optimal solutions. If perturbation can be used to eliminate multiple optimal solutions, however, it also can be used to generate them (as in the case of almost multiple optimal solutions). Contrary to McCarl's approach, we suggest that the existence of multiple optimal solutions renders the problem richer in information and more interesting to deal with.

The conditions under which multiple primal and dual optimal solutions can occur in linear programming problems are related to the phenomenon of degeneracy, a rather plausible situation in empirical studies. Degeneracy of the primal solution occurs when a set of activities employs inputs in exactly that proportion which exhausts completely two or more available resources. Analogously, degeneracy of the dual solution is encountered when, given an optimal plan, the accounting loss for some nonbasic activity happens to be the same (zero) as that of the activities included in the optimal plan. Hence, the likelihood of either primal or dual degeneracy increases rapidly with the size of the model. Baumol (p. 315) asserts that "computational experience indicates that such cases (primal and dual degeneracy) are encountered more frequently than might be expected in advance." Thus, a correct and informative report of empirical results generated by LP should include complete information about the problem's size and an explicit statement of whether the primal and dual solutions presented are indeed unique.

Unfortunately, a search of the empirical literature has revealed that a majority of papers fail to disclose even the number of columns and rows in the matrix of constraints. No paper mentioned whether or not the reported solutions are unique.

Dealing with Multiple Optimal Solutions

Given the substantial effort and amount of data usually involved in the specification of large LP models, multiple optimal and quasi-optimal solutions should not be regarded as a curse. They are merely processed information incorporated in the model from the start for thoughtful researchers to be aware of. The curious reader, on the other hand, should know about them to appreciate fully the model's capabilities. Reporting of all optimal and quasi-optimal solutions, therefore, does not seem a priori an excessive burden. The informational content of such a reporting easily may outweigh the initial cost of assembling the model.

Two seemingly unrelated ideas provide a plausible criterion to help the researcher in choosing among various optimal solutions. The first is that a convex combination of optimal solutions is itself an optimal solution. This idea can provide an unexplored flexibility for the application of LP meth-

ods to empirical problems. As is well known, the number of positive activity levels included in an extreme point optimal solution cannot exceed the number of constraints. But this restriction is not applicable to convex combinations of extreme point solutions. Hence, the possibility of more diversified optimal solutions should not be ignored.

The second idea is that researchers have often judged their LP models by comparing their performances (in terms of an optimal solution) with actual behavior of the economic agent under study. In the presence of dual degeneracy, this criterion implies choosing the convex combination of optimal solutions in closest proximity to actual activities.

To combine these two ideas, a familiar minimum distance criterion based on minimizing a quadratic loss function, can be used.

Consider the LP problem of choosing a vector $\mathbf{x}$ to

(1) maximize $c'\mathbf{x}$ subject to $\mathbf{A}\mathbf{x} \leq b$, $\mathbf{x} \geq 0$,

where $\mathbf{A}$ is an mxn matrix of known coefficients and the other elements of the problem are conformable to it.

Suppose problem (1) represents a regional production location problem and possesses k alternate primal optimal solutions, $k<n$. Let $\mathbf{P}$ be the matrix whose column vectors are such k-extreme point optimal solutions. Let $\mathbf{x}_a$ be a vector of activity levels actually operated in the region. Then, the problem of choosing a vector $\mathbf{w}$ to

(2) minimize $(\mathbf{x}_a - \mathbf{P}\mathbf{w})' (\mathbf{x}_a - \mathbf{P}\mathbf{w})$ subject to $\mathbf{s}'\mathbf{w} = 1$, $\mathbf{w} \geqslant 0$,

defines a procedure to estimate the weights, $\mathbf{w}$, for the convex combination, $\mathbf{P}\mathbf{w}$, of the k-extreme point optimal solutions. The components of the vector $\mathbf{s}$ are all unitary. The optimality criterion is the least-squares problem of choosing that optimal LP solution, $\mathbf{P}\hat{\mathbf{w}}$, which is closest to the activity levels actually operated in the region.

The formulation of problem (2) is appealing for several reasons. First, the objective function can be viewed as a measure of the loss incurred by the region for not producing according to optimal activity levels that require minimum deviations from present practices. Second, the matrix $\mathbf{P}$ is of full column rank since the optimal solutions that define it are associated with extreme points and are, therefore, independent of each other. Hence, the solution vector of weights, $\hat{\mathbf{w}}$, is unique and, in turn, the projection $\mathbf{P}\hat{\mathbf{w}}$ constitutes an optimal LP solution which itself is unique in the sense defined by problem (2). The components of the $\mathbf{w}$ vector are scalars without unit of measurement because they represent weights of a convex combination. Therefore, changes in the measurement units of the LP activities considered in the model do not affect the estimates of $\mathbf{w}$. In fact, the components of every column in the $\mathbf{P}$ matrix represent the same activities as in the $\mathbf{x}_a$ vector. If measurement units are changed for some activity in the model, they are changed in both the $\mathbf{P}$ matrix and the vector $\mathbf{x}_a$, offsetting each other. Third, if the vector $\mathbf{x}_a$ is a random sample of activity levels—as is usually the case with econometric studies—it is possible to apply the standard statistical procedures to verify hypotheses of how closely the LP model explains the behavior of economic agents.[2] Therefore, when there are multiple optimal solutions, finding a plausible optimal solution of LP problems generally involves a two-stage optimization process. In the first stage, all extreme point optimal solutions are generated. In the second stage, optimal weights are computed to collapse them into an optimal (least distance) convex combination.

The two-stage optimization procedure outlined above is a novel blend of mathematical programming and inferential, statistical technique. In mathematical programming, the researcher assumes knowledge of the problem's structure and asks: What is the optimal response associated with it? In statistical inference, one starts with "real world" observations and asks: What is the most likely structure which generated such observations?

This sharp dichotomy is useful only as a classification scheme. In reality, each approach shares some distinctive features of the other. Thus, on one hand, linear programming models are specified using real world observations in their constraints, input-output coefficients, and revenue vector. Econometric models, on the other hand, assume some elements of the structure of the problem that will constitute the maintained hypothesis. The additional link between mathematical programming and econometrics is represented by the vector of realized activity levels, $\mathbf{x}_a$, which allows a test of the null hypothesis whether or not the linear programming structure is suitable for the problem under investigation.

Approaching the problem of multiple solutions by computing an optimal convex combination, indicated in problem (2), has the advantage of making the most use of all the information contained in the original LP specification. This does not imply that the best-fit solution is preferred to others. But, if a planned optimal solution is implemented by an economic agent, the solution which requires minimal adjustments from present practices ought to be carefully considered.

Validation of LP Models

A survey of the empirical literature reveals that validating LP models vis-à-vis the economic reality they intended to reflect was not often an explicit and formal objective. This is in sharp contrast with econometric and simulation studies in which the

[2] In econometric studies, the observations of realized activity levels, $\mathbf{x}_a$, are assumed to constitute a random sample suitable for hypothesis testing. The character of the $\mathbf{x}_a$ vector does not change when used in the context presented here.

validation process is widely recognized as an essential part of the analysis.

The multiple optimal solution problem clearly shows the necessity of including formal model validation within the LP analysis. To develop a more complete and satisfactory procedure, it seems logical to parallel the inferential methodology of econometrics. Despite their apparent differences, there is a strong analogy between the logical structure of econometric and mathematical programming studies.

In econometric studies, the structural model is always the result of an implicit optimization process assumed to underlie the behavior of economic agents. That is, economic agents are assumed to maximize utility, profit, or expected utility. In linear programming, such an optimization process is always explicit and corresponds to the LP model itself. The LP constraints can be regarded as structural form relations.

In econometrics, the inferential process and validation methodology rely upon two fundamental steps: identification and hypothesis testing. Linear programming analysis, especially when multiple optimal solutions occur, faces the same twofold process. To be sure, the large size of most empirical models tends to reduce the importance of the identification problem. Formally, such a problem can be stated as follows: given the LP structural form relations $Ax \leq b$, is it possible to find a matrix $\mathbf{T}$ such that the system $\mathbf{T}Ax \leq \mathbf{T}b$ is equivalent (possesses the same optimal solutions) to $Ax \leq b$? If the $\mathbf{T}$ matrix exists and is not an identity matrix, the LP structural forms are not identified.

The reduced-form relations of an LP model are given by the quadratic loss criterion (2). In this case, $\mathbf{x}_a = \mathbf{P}\mathbf{w} + u$, $1 = \mathbf{s}'\mathbf{w}$, $\mathbf{w} \geq 0$, constitutes the LP reduced forms. Hypothesis testing, associated with these reduced forms, can be interpreted as a validation procedure of the LP specification. If the LP model is identified and the difference between the sample observations $\mathbf{x}_a$ and the projection $\mathbf{P}\hat{\mathbf{w}}$ is not statistically significant, one can conclude that the LP specification "explains" the behavior of the economic agents whose decisions are revealed by the vector $\mathbf{x}_a$. In other words, the LP model is validated. If the difference $(\mathbf{x}_a - P\hat{\mathbf{w}})$ is statistically significant, the LP model probably is not appropriate, and an alternative formulation should be sought. This is no different from the conclusion to be derived from econometric studies.

As with econometrics, a high level of "goodness of fit" cannot be taken as an exclusive index of model validity. On the other hand, the structure of LP studies is usually given a more explicit and (perhaps) thorough consideration than with econometric models. Thus, a high level of "goodness of fit" and a thoughtful specification of the LP structure and its identification may provide convincing support for not rejecting the model. Conversely, a low level of "goodness of fit" could induce the researcher to search for a better specification of the structural LP relations.

Multiple Optimal Solutions and Economic Equilibrium

The existence of multiple optimal solutions may serve, in principle and by itself, as a validation of economic models analyzed by linear programming. Consider, for example, profit-maximizing entrepreneurs who are assumed to operate in a perfectly competitive environment using homothetic technologies. If these assumptions hold, it is well known that first-order conditions imply that inputs are used in constant proportions to each other. The expansion path is a ray. In empirical data, these necessary conditions (expressed as exact or quasi-linear dependence) generate multicollinearity, usually disliked by the econometrician. Doll, however, in a perceptive reexamination of the problem, pointed out that "users of the(se) . . . model(s) who are dismayed to find multicollinearity among the 'independent' variables should be pleased because the presence of multicollinearity serves as a verification of their economic model" (p. 558).

This observation has its counterpart in linear programming models. If the firms analyzed by linear programming are assumed to operate under perfectly competitive conditions, and if the LP model is really capable of reflecting such an environment, one would expect many nondominated activities to be equally profitable, whether or not they are included in the optimal basis. This is because zero profitability is a long-run necessary condition for competitive markets. In general, commodities are available in these markets in larger number than the LP constraints of a single firm.

Let us reformulate this idea as follows: In a competitive situation, where there are many firms using essentially the same technology, one observes that similar firms produce different product mixes. In the absence of uncertainty, all activities are equally profitable and, therefore, it just happens that one firm chooses a particular combination of activities while others select a different mix. In LP terminology, this situation is characterized by zero relative loss not only for the optimal basic activities but also for those not in the basis. It causes the multiple optimal solution phenomenon. Hence, an extensive dual degeneracy may be interpreted as a validation of an LP economic model, where perfect competition and certainty prevail. Of course, it is unlikely that any large-scale LP model will exhibit zero profitability for all nonbasic activities. For this reason, validation of the model must take the form of a probabilistic statement.

Conclusions

This paper has accomplished several tasks. It has drawn attention to a neglected but important problem in empirical studies using an LP framework. It has outlined a more complete way of reporting LP results which includes not only the exact problem size but also an explicit statement about the

uniqueness (or multiplicity) of primal and dual solutions. It has suggested a plausible criterion for dealing with the choice created by the existence of multiple optimal and quasi-optimal solutions. It has argued for more formal validation procedures of LP models and for the reporting of a best-fit solution along with the other optimal solutions from which it is derived. In summary, it has suggested that the analysis of empirical problems using linear programming should not be conducted in the simplistic and mechanical way of the past thirty years. This is especially true when the goal of the study is either an efficiency judgement or the recommendation of a new policy.

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Minimizing Mean Absolute Deviations to Exactly Solve Expected Utility Problems

Donald Johnson and Michael Boehlje

Quadratic programming (QP) procedures have been used widely in expected utility analyses. Yet, in a recent research project, we encountered numerous problems obtaining QP solutions.[1] Approximating techniques, such as MOTAD (minimization of total absolute deviations), MRC (marginal risk constrained programming), and separable linear programming (Hazell, Chen, Thomas et al.), were developed to overcome similar problems. Their merits have been determined primarily by comparing solution variances to QP solution variances, with all comparisons made at equal means. Most analysts feel that QP is preferable for small models; approximating techniques are only appropriate in large models when QP is impractical.

Proposition

In our work, we assumed that mean-variance analysis (or QP) is a means of solving an expected utility problem. We argue elsewhere that for certain symmetrically distributed variables, the QP solution includes those activities with maximum expected utility for that mean value (Johnson and Boehlje).[2] In other words, the set of activities with the lowest variance (for a given mean) also has the highest expected utility. Likewise, the validity of using alternate techniques should be based on how well they approximate expected utility solutions, not QP solution variances. To that end, we propose the following: if (*a*) two variates Y_1 and Y_2 are symmetrically distributed with the same means, and (*b*) density functions $f_1(y)$ and $f_2(y)$ are such that $f_1(y) \geq f_2(y)$ everywhere in the region $\mu - d < y < \mu + d$ (with strict inequality for at least one interval in the region) and elsewhere $f_2(y) \geq f_1(y)$, then $f_1(y)$ will have the smaller variance and also the smaller MAD (mean absolute deviations).

Figure 1 shows two density functions which satisfy the above conditions. Specific functions which will satisfy these conditions include the normal, double exponential, and triangular.

Proof

The function $f_1(y)$ has less weight in its tails than does $f_2(y)$; so variate Y_1 has a smaller variance than does Y_2 (Rothschild and Stiglitz). Since both variables are symmetric, the following inequality expresses the relationship between variances:

$$(1)\quad 2\int_{\mu}^{\infty}(y-\mu)^2 f_1(y)\,dy < 2\int_{\mu}^{\infty}(y-\mu)^2 f_2(y)\,dy, \text{ or}$$

$$\int_{\mu}^{\mu+d}(y-\mu)^2 f_1(y)\,dy + \int_{\mu+d}^{\infty}(y-\mu)^2 f_1(y)\,dy$$

$$< \int_{\mu}^{\mu+d}(y-\mu)^2 f_2(y)\,dy + \int_{\mu+d}^{\infty}(y-\mu)^2 f_2(y)\,dy,$$

and finally,

$$\int_{\mu}^{\mu+d}(y-\mu)^2\,[f_1(y) - f_2(y)]\,dy < \int_{\mu+d}^{\infty}(y-\mu)^2[f_2(y) - f_1(y)]dy.$$

Next, two nonnegative functions can be defined

$$g(y) = f_1(y) - f_2(y),\ \mu < y < \mu + d; \text{ and}$$
$$h(y) = f_2(y) - f_1(y),\ \mu + d < y < \infty.$$

Since symmetric variables have one half their probability in their right tail, the amount by which the probability mass of $f_1(y)$ exceeds $f_2(y)$ in the region $\mu < y < \mu + d$ is exactly offset by the amount by which $f_2(y)$ exceeds $f_1(y)$ in the region $\mu + d < y < \infty$, or

$$(2)\qquad \int_{\mu}^{\mu+d} g(y)\,dy = \int_{\mu+d}^{\infty} h(y)\,dy.$$

The above regions can each be subdivided into n smaller regions (indexed by i) such that

$$(3)\qquad \int_{g_i} g_i(y)\,dy = \int_{h_i} h_i(y)\,dy$$

for $i = 1, \ldots, n$.

For each of the regions of equal area, it is also true that

$$(4)\quad \int_{g_i}(y-\mu)^2 g_i(y)\,dy < \int_{h_i}(y-\mu)^2 h_i(y)\,dy,$$

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[1] We used a RAND code which must solve in computer memory. Large models were costly to solve and, in one case, exceeded internal storage capacity. Also we were not able consistently to obtain feasible solutions until we changed default parameter specifications and tolerances. The default parameter values we used are available upon request.

[2] This requires that density functions meet the conditions outlined in the proposition and that utility functions have derivatives which alternate in sign, beginning with a positive first derivative.

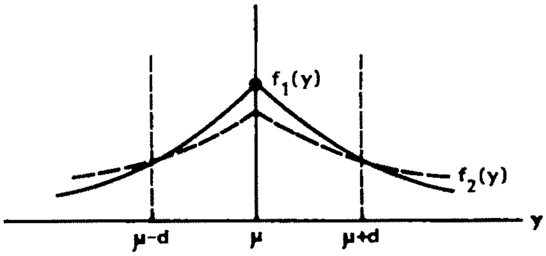

Figure 1. Density functions satisfying the proposition

since the $(y - \mu)$ values in the h_i regions are always greater than the $(y - \mu)$ values in the corresponding g_i regions. For the same reasons, it is also true that

$$(5) \qquad \int_{g_i}^{\infty} |y - \mu|\, g_i\,(y)\, dy < \int_{h_i} |y - \mu|\, h_i(y)\, dy$$

for all i. Then it can be shown that

$$(6) \qquad 2\int_{\mu}^{\infty} |y - \mu| f_1(y)\, dy < 2\int_{\mu}^{\infty} |y - \mu| f_2(y)\, dy,$$

or that variate Y_1 has smaller MAD than does variate Y_2.

Implications

If working with certain symmetric variables, e.g., a normal variate, then either minimizing MAD (using MOTAD) or minimizing variance (using *QP*) would lead to selection of the same random variate.[3] True, there is error in estimating variance through MAD, but one is really concerned with relative rankings among a set of variables. Theoretically, MOTAD would do this ranking as accurately as would quadratic programming.

In practice, QP and MOTAD solutions may not be identical. If true distributions are unknown, historical data are generally used to estimate parameters. In a QP model, sample estimates of the variance are used to find the lowest variance solution for each mean. Error can result, since the solution with lowest population variance may not be selected by the program. Likewise, in MOTAD, historical observations are used to calculate sample mean absolute deviations. Error again can result because sample estimates will not be the same as the population parameter.

Minimizing mean absolute deviations (or MOTAD) is theoretically as valid as quadratic programming in solving expected utility problems under the previously outlined assumptions. Theoretically, both techniques would give the same result; however, inaccuracies arising from using sample values may lead to different empirical results. The conditions outlined in this paper include normal distributions and quadratic utility functions as special cases—both frequent assumptions in agricultural risk studies.

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[3] This would be true if the utility function were quadratic, negative exponential, or logarithmic.

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Capital Gains versus Current Income in the Farming Sector: Comment

John P. Doll and Richard Widdows

In the December 1979 issue of this *Journal*, Melichar compares estimates of capital gains in agriculture to the returns earned by productive assets in agriculture. As a result of his analysis, which was based on data from the balance sheet calculations of Evans, Melichar concludes: "It thus appears that both recent real capital gains and those of 1954–67 are, in a sense, fully explained by the growth exhibited by the current return to assets" (p. 1090). These findings have special significance at a time when the "conventional wisdom" of the profession seems to be suggesting that recent land value increases are based on speculative forces rather than asset earnings. Melichar shows that when asset earnings are expected to grow then, "a significant portion of the total return to farm real estate necessarily takes the form of real capital gains" (p. 1091).

Melichar's analysis is based upon an asset valuation model that has as a key assumption the constant growth rate of earnings. The purpose of this comment is to extend the description of the model used by Melichar and thereby suggest some further tests of its applicability to agriculture.

The Valuation Model

Using the formulation presented by Harris in the same issue of the *Journal*, the present value of an asset that is to be held n periods is given by

$$(1)\quad V_n = \frac{(1+g)}{(1+d)} R_0 + \frac{(1+g)^2}{(1+d)^2} R_0 + \dots + \frac{(1+g)^n}{(1+d)^n} R_0,$$

where V_n is the present value, R_0 is the amount the asset earns at time zero, g is the expected growth rate in earnings over time, and d is the discount rate applied to future earnings. If the asset is to be held $n+1$ periods, then the present value can be written

$$V_{n+1} = \frac{(1+g)}{(1+d)} R_0 + \frac{(1+g)^2}{(1+d)^2} R_0 + \dots + \frac{(1+g)^{n+1}}{(1+d)^{n+1}} R_0$$

$$V_{n+1} = \frac{(1+g)}{(1+d)} R_0 + \frac{(1+g)}{(1+d)} \left[\frac{(1+g)}{(1+d)} R_0 + \dots + \frac{(1+g)^n}{(1+d)^n} R_0 \right]$$

$$(2)\quad V_{n+1} = \frac{(1+g)}{(1+d)} R_0 + \frac{(1+g)}{(1+d)} V_n.$$

In equilibrium, by definition $V_{n+1} = V_n = V_e$. Substituting V_e into (2) gives Melichar's first equation (p. 1088):

$$(3)\quad V_e = \frac{(1+g)}{(1+d)} R_0 + \frac{(1+g)}{(1+d)} V_e;$$

and solving for V_e gives Melichar's second equation,

$$(4)\quad V_e = \frac{(1+g)}{(d-g)} R_0.$$

The equilibrium value, V_e, is in fact the sum of the infinite series obtained by assuming that the asset produces into perpetuity. This can be rationalized from (1) as follows: At the end of n periods, the asset may be sold and the sale value discounted back to the present. But the sale value is determined by the earnings from time $n+1$ into the future. Each time the asset is sold, earnings are again extended into the future, and hence, without limit. As long as $d > g > 0$, the infinite series has the limit V_e. This limit can be derived directly (Van Horne, p. 22, and Reilly, p. 301).

Interpretation of Equilibrium

When interpreting the equilibrium, Melichar states: "For this asset, real capital gains arise in two ways. First, changes in the value of R, g, or d result in a new equilibrium value V, and the amount of change in V is a real capital gain. Second, if the growth rate g is greater than zero, the equilibrium value V rises each year even though the values of g and d are unchanged; that is, annual capital gains are an inherent feature of the equilibrium condition" (p. 1088).

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Equation (4) presents the equilibrium value of the asset, which is the sum of a convergent infinite series. This value is unique, given values for d, g, and R_0, where $d > g > 0$. V_e will increase as g and R_0 increase and decrease as d increases, but V_e will not change unless one or more of these three variables change. Viewed another way, if the realization of R_0 or expectation of d or g change at a given point in time, then V_e will change at that point in time. This would be comparative statics in the usual sense. Thus, Melichar's first conclusion above follows directly from equation (4).

Next, assuming that the expected growth rate g is realized each year, asset earnings would be $R_1 = (1 + g) R_0$ at the beginning of the second period, $R_2 = (1 + g)^2 R_0$ at the beginning of the third period, and, in general, $R_t = (1 + g)^t R_0$ at the beginning of the tth period. Extending this reasoning, the equilibrium value of the asset through time would be

$$V_{et} = \frac{1 + g}{d - g} R_0 (1 + g)^t, \tag{5}$$

where V_{et} is the value of the asset at the beginning of year t, and the first value of t is zero. This formulation follows directly from the discussion following equation (4), where expectations are continually realized.

The panels in Melichar's table 2 (p. 1090) can be derived directly from equation (5). The values in panel A, equilibrium asset value per dollar of current return, are given by the ratio $[V_{et}/R_t = (1 + g)/(d - g)]$. This is a concept using earnings that is similar to the "dividend" multiplier defined by Reilly (p. 265) as $[V_{et}/R_{t+1} = 1/d - g]$, which compares earnings at the end of the period to asset value at the beginning of the period.

Panel B, annual capital gain as a percentage of asset value, is given by

$$\frac{V_{e(t+1)} - V_{et}}{V_{et}} = g.$$

Panel C, annual current return as a percentage of asset value, is given by $[R_{t+1}/V_{et} = (d - g)]$, when annual current return is assumed to measure earnings at the end of the period. It is the inverse of the earnings multiplier and, as Melichar suggests, is important because it determines how the total return is divided between a capital gain and a current return.

Finally, Panel D, annual capital gains as a percentage of annual current return, is given by

$$\frac{V_{e(t+1)} - V_{et}}{R_{t+1}} = \frac{g}{d-g}.$$

The results for Panels B, C and D must be converted to percentages.

To review the assumptions, equation (1) requires, in addition to the usual assumptions for discounting future returns, the assumption of a constant growth in earnings for a period of length n. The sale value of the asset in period n could be added to the equation and discounted back to the present. No stipulation need be made concerning the relative magnitudes of d and g. To obtain equation (4), the additional assumptions required are that the growth rate g is perpetual and that d, which is defined as the discount rate or the required rate of return, must exceed g. If estimates of d are based on opportunity cost, such as a market rate of interest, then determination of V_e using (4) requires that these external rates of interest exceed the rate of growth of earnings within the firm into perpetuity. Investors might use equation (4) to revalue assets annually, revising their estimates of d, g, and R_0 as appropriate. But, equation (5) will result when these expectations are perpetually stable.

Evaluating the Model

Equation (4) would appear to be difficult to test using time-series data. If investors change their expectations of d, g, and R_0 on an annual basis, then the equilibrium value of the asset will change accordingly. Increases in land values, such as those experienced recently, could result from expectations of increased earnings, increased growth in earnings, or both.

Testing equation (5) should be easier. If expectations of all quantities are stable, then examination of equation (5) suggests that asset values should grow at the same rate as asset earnings.

As a first step, we computed the growth rates for asset earnings and asset values for the time periods selected by Melichar in table 1 (p. 1089). (The data were obtained from the more detailed paper presented by Melichar at the summer meetings.) Following his suggestion, growth rates for returns were computed from the value in the year preceding the period (except for 1954–60) to the value in the last year of the period, while growth rates for assets were computed between the first year in the period and the 1 January value of the first year following the period. The growth rates obtained were as follows:

	Earnings (%)	*Asset Values*
1954–60	3.4	5.0
1961–67	8.0	5.2
1968–71	6.7	5.3
1972–78	13.4	13.2

From a value standpoint, real estate is the major component of asset values—approximately 90% in 1978. Thus, growth rates in real estate values differ only slightly from the growth rates in asset values.

Returns in agriculture are quite variable, while asset values (with isolated exceptions) have increased steadily over the past thirty years. Thus, the growth rates for earnings presented above may depend unduly upon the endpoints of the periods selected. To avoid this, we estimated growth rates using least squares regression. Lacking better crite-

ria and to avoid excessively small samples, we estimated growth rates for each decade and the entire period. The resulting growth rates were the following:

	Earnings		*Asset Values*
		(%)	
1950–59	−5.3		3.7
1960–69	7.3		4.8
1970–79	8.7		11.5
1950–79	6.9		6.1

Thus, while growth rates differed markedly within decades, growth rates for earnings and assets were remarkably similar for the thirty-year period.

The estimates presented suggest that asset earnings and asset values in agriculture are not perpetually growing at the same rate. If they were, their growth rates would be invariant to the time period selected. Moreover, the regression results suggest that asset earnings grew about three percentage points faster than asset values in the sixties, but the growth rates were reversed in the seventies. The more rapid growth of earnings in the sixties might be attributed in part to a recovery from the depressed earnings of the fifties. But, because the time periods were selected arbitrarily, we would hesitate to draw strong conclusions, even though the least-squares estimates are less susceptible to the selection of endpoints.

The key to all of this would appear to be the manner in which investors form expectations. It seems to us that Melichar is correct in concluding that growth in earnings is having an important (and hitherto overlooked) effect on asset values. But, we also believe equation (5) may provide too restrictive a view of what actually is happening. Investors may be reformulating growth rates, as well as the value of initial earnings, on an annual basis in such a way to cause the more rapid growth rate in asset values evidenced in the seventies. Some of the models that have been developed recently, for example by Lee and Rask, Harris and Nehring, or Plaxico and Kletke, which consider many factors, such as capital gains taxation rates, might be used to shed light on why asset values grew faster than asset earnings in the seventies.

As an alternative, we examined Melichar's results using the more traditional analyses presented in finance textbooks. Such analyses are commonly based on the assumption that investors value assets using equation (4) and reevaluate expectations annually.

The attached table 1 was developed from Melichar's data. The value of production assets on 1 January, used as estimates of V_e, were divided by the annual earnings of production assets, representing R_1. Assuming that investors do use the earnings growth model to place values on assets, then the numbers in the table represent estimates of the coefficient $(1/d - g)$, the earnings multiplier referred to above.

Table 1. Value of Farm Production Assets per Dollar of Earnings

Year	Assets/$	Year	Assets/$	Year	Assets/$
1950	16.1	1960	33.2	1970	24.4
1951	16.1	1961	27.8	1971	24.4
1952	20.6	1962	25.9	1972	17.8
1953	30.1	1963	27.0	1973	9.9
1954	29.3	1964	30.9	1974	16.0
1955	37.1	1965	21.2	1975	18.7
1956	36.1	1966	20.3	1976	28.6
1957	33.5	1967	26.3	1977	31.1
1958	22.7	1968	27.8	1978	22.7
1959	44.6	1969	23.8	1979	22.1

Source: Melichar.

In 1979, each $22.1 of agricultural assets earned $1 of income. This ratio was lower than 22 only nine times in the previous twenty-nine years. In fact, the asset/earnings ratio was much higher in the late fifties when it moved above 30 four times and achieved an all-time high (in the sample period) of 44.6 in 1959. From this, we would have to conclude that if assets were overvalued in 1978 and 1979, then they also have been overvalued most years since 1950.

Another application uses the equilibrium value equation to determine what Van Horne, on page 22, calls the "expected" return. From equation (4), the expected return is

$$d = \frac{R_1}{V_e} + g,$$

which is the economists' discount rate or required rate of return. Again, assuming equilibrium, earnings as a percentage of production assets can be used to estimate the ratio R_1/V_e. These returns are the inverse of the numbers in our table, expressed as percentages. The growth rate in earnings estimated by regression for 1970–78 was 8.7%. This is, of course, dependent upon the period selected, and may not represent a time period used by investors. As an alternative, we computed the growth rate between the average earnings for the decades of the sixties and the seventies. Assuming that the averages are also separated by ten years, they grew at about 10%. Using these as high and low estimates, the "expected" return for agriculture was between 13.2% and 14.5% for 1979. Further, it could have been as high as 20% in 1973 and as low as 11.9% in 1977.

Thus, another way to interpret the application of the earnings growth model would be to say that if, in 1979, an earnings growth rate of 10% and a discount rate of 15% prevailed, then production assets were not overvalued relative to earnings. Of course, d and g are not unique; the pairs d = 0.10

and $g = 0.05$ or $d = 0.05$ and $g = 0.0043$ also would result in a valuation of twenty-two times earnings. Thus, the lower the farmer's discount rate, the lower must be the growth in earnings to justify a given value level, and vice versa.

Finally, rather than using equations (3), (4), or (5), equation (1) might be used directly to evaluate the applicability of the earnings growth model to agricultural data. Equation (1) does not require the assumption of an infinite time horizon, a perpetual growth rate, or even the assumption that d exceeds g. Reilly suggests (p. 373) that g will exceed d in growth firms, but only for short periods, because no firm can outgrow the market perpetually. Van Horne (p. 23) provides a variation of equation (1) that permits the use of different growth rates during transitional periods. Thus, while the equations (3), (4), and (5) provide convenient mathematical summations of the valuation problem, equation (1), which would require computer solutions, appears to offer a potential for solutions richer in interpretation. The results, of course, would depend on how well researchers could approximate the manner in which investors form expectations of the parameters of the model.

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Capital Gains versus Current Income in the Farming Sector: Reply

Emanuel Melichar

Doll and Widdows (D-W) describe the model that characterizes the relationship between asset earnings and market value and show how the rates of return from earnings and capital gains are linked to earnings growth rate, relationships illustrated in table 2 of my original article. Readers studying may draw upon our combined text, algebra, and tables.

This asset valuation model is no stranger to many agricultural economists. I originally came to it by simplifying land valuation models presented by Lins (p. 15) and Willett and Wirth (pp. 19–20), models designed for analysis of individual land purchases and including tax rates, planning periods, inflation, and terms of debt financing (variables which D-W suggest might be considered in future analyses). Both models also differed from the one discussed here in allowing users to enter one projected growth rate for earnings and, if desired, a different—presumably higher—projected growth rate for land prices. This reflected the general impression that land prices had been rising faster than earnings—a view apparently based on the divergent trends of the USDA's net farm income and land price series rather than on actual investment experience. While Willett and Wirth advised users of their valuation formula: "If land use is restricted to agricultural enterprises, the change in market price should be similar to the rate of change estimated for annual agricultural returns" (p. 11), they had stated earlier that "there has been a growing disparity between farmland value and earnings from that farmland" (p. 1).

After showing that net farm income does not measure asset earnings and that the long-term growth rate of actual asset earnings may be even higher than that of asset values or farm land prices (Melichar 1978), the model demonstrates that this earnings growth provides the chief explanation for two empirical observations that have puzzled economists: (*a*) the rise in real land prices and (*b*) the relatively low rate of current earnings of farm assets (that is, the relatively high asset/earnings ratio). The first outcome is self-evident; an asset price should rise or fall at the same pace as its earnings, *ceteris paribus*. The second result is logically more subtle, the arithmetic is simple, and the policy implications are remarkable.

To know whether the model, its empirical consequences and their policy implications are of practical significance, one needs to know how the growth record of earnings compares with that of assets. This Doll and Widdows empirically explore. It is enlightening to note here that the general nature of the comparative behavior of these series has been implicitly known to agricultural economists for many years and that it has been implicit in a major empirical finding and teaching of the profession. Have we not taught that the rate of return has remained at 3%–4%, on average, for several decades, and implicitly taught that earnings have risen as fast as equity? Have we not observed an upward tendency in the ratio since its post-Korean War lows and thought this trend logical in view of the improving relationship between aggregate demand and farm production capacity? We have implicitly observed that earnings have risen somewhat faster than equity over the whole period and that equity recently has been priced at a lower multiple of earnings than in the mid-1950s. Have we not been aware of the sizable rise and fall in the rate of return over certain periods, particularly during the Korean War and again in 1972–77? We have known that rates of change in earnings and assets have differed greatly over certain shorter periods, even as their longer-term trends have been similar. To transfer this body of knowledge to the present discussion, we need to note that adding debt to equity and interest to earnings does not greatly alter the general level, trend, or cyclical behavior of either series or their ratio (see chart 2, p. 200, Melichar 1978).

Hence, the empirical record scrutinized by D-W already has been explored and accepted by our profession. With the asset valuation model seen as consistent with the asset and earnings data, we now can confidently state that the increase in farm asset value reflects increased farm earnings, and that the low present earnings rate (or high asset/earnings ratio) reflects the expectation of continued future earnings increases. (This is an important correction to a similar statement by Schertz and Harrington, p. 61.) Thus, there is urgent need to study the causes of past earnings growth, prospects for future growth, and policy implications of various growth rates.

Before elaborating on these suggestions, however, a few specific comments are in order on

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asset earnings and asset values. Their first comparisons are made in nominal terms for the same periods for which I had reported similar real-term comparisons; thus our results are similar, with our reported rates differing mainly by the rate of general price inflation by which I had deflated my asset and earnings variables. D-W note that the relationship between the growth rates of assets and earnings changes from one period to the next. This is hardly surprising, however, as I had selected those specific time spans "on the basis of differences either in the growth rate of the current return . . . or in the relative importance of capital gains" (p. 1088). Furthermore, D-W employ a technically inferior asset variable, and thus my original comparisons might be preferable. The latter deficiency also occurs in their second set of comparisons, in which decades are the periods examined and least-squares regression is used to estimate growth rates. More seriously, this second set produces misleading values for earnings growth in two of the three decades because of the presence and timing of a large cyclical swing in earnings within each decade.

The technical flaw in calculating growth rates for unadjusted asset values as D-W did is that such values rise or fall as a result of net investment and intersector transfers as well as of price changes; and, for our purpose, the growth rate desired is that due to asset price changes only. For their calculations in nominal terms, D-W should have constructed an asset variable whose values change only as nominal capital gains or losses are experienced. In my parallel work in real terms, I reported the average rate of real capital gains on physical assets (table 1, column C × column B). In addition, because only the real estate component of farm assets is likely to reflect capitalized earnings, and because in some periods there are noticeable differences between rates of price change for total assets and real estate, I also reported the average rate of real capital gains on real estate alone (column D). (Real estate comprised only 80% of total farm production assets in 1978, rather than 90% as D-W state. Earlier in the 1950–79 period, proportion was as low as 66% [Hottel and Evans, p. 63]. Thus the growth rates of adjusted assets and real estate probably differed somewhat.) D-W may not have recognized that these results were asset growth rates, as they do not mention them. Adjustment for net investment and transfers was minor relative to price change size; thus our results are similar. For the specified time, we both find that, as compared with the earnings growth rates, those of assets were somewhat higher in 1954–60, considerably lower in 1961–67, somewhat lower in 1968–71, and about the same in 1972–78.

The misleading earnings growth rates D-W report for the 1950s and 1970s are more serious because they are led to believe that asset growth in the latter decade significantly exceeded earnings growth. While such divergence could have resulted from a change in expected real earnings growth or in the real discount rate (required rate of return), this does not appear to have occurred. The years of exceptionally high earnings, 1972–74, occur in the first half of the decade; the two years of lowest earnings occur in the second half. When a semilogarithmic least-squares regression line is estimated through this up-down-up cycle, its slope is flattened and both slope and position are unrepresentative of the decade's earnings. It also differs from the common view of the longer-term course of earnings in that period, which would be instrumental in asset pricing. Few persons thought that earnings could be sustained at the exceptional level of 1973; later low earnings of 1976–77 were viewed similarly, as a downside aberration. In 1978–79 earnings seemed to be "on track." Hence, I chose to draw an earnings trend from the 1971 to the 1978 value, a trend which has a growth rate about equal to that of assets and real estate prices.

The same point may be made through an alternative approach facilitated by D-W's table 1. If asset values did rise faster than earnings in the 1970s, as D-W conclude, then the asset/earnings ratio in their table 1 also must have risen. In fact, given their least-squares results, the ratio should have risen by 2.9% annually (the difference between their least-squares asset and earnings growth rates). Does inspection of their data indicate that the asset/earnings ratio rose by almost one-third over the decade? No, a reasonable impression is that, after the gyrations of 1972–77, the ratio remains at about the level at which it entered the decade, or perhaps has fallen slightly. Thus the least-squares result, caused by the presence and position of the severe earnings cycle, is misleading. Similarly, if the asset/earnings multiple has not risen, neither the expected real earnings growth rate nor the real discount rate has changed (with the possible exception of offsetting movements).

Future work on these past empirical relationships should employ recently revised USDA earnings series (Hottel and Evans; USDA, pp. 53–54), presenting data back to 1940. The return to production assets, although calculated as a residual, is probably about as reliable as the total net farm income series, since actual farm wage rates and management fees are available for use in calculating imputed charges for operators' labor and management. In addition, one can take comfort in knowing that studies using landlords' rent rather than residual earnings have consistently produced similar findings in stable agricultural areas (Reinsel, Dobbins et al.). The reliability of the asset series basically depends on the accuracy of the USDA survey of farm real estate prices, but in addition there is some uncertainty about the appropriate adjustment for net investment. The balance sheet of the farming sector, on which I based my capital gains calculation, shows that the physical stock of farm real estate increased by 5.5% 1960–78 (Evans, p. 8),

whereas another account indicated net disinvestment of $30.8 billion (Evans, p. 40). In addition to using revised and improved data, future analyses might try to employ valuation models that include considerations such as tax rates and financing terms.

At this stage in the development of our new insights there seems to be more to be learned from investigating past causes and future prospects of real asset earnings growth. In the mid-1960s, Chryst, and Herdt and Cochrane almost found the key to the asset/earnings relationships but then missed it and concluded that government price support and supply reduction programs, when combined with ongoing cost-reducing, output-increasing technological advances, tended to increase asset earnings. The authors, however, were unable to break through their entrenched image of a flat net farm income. Chryst decided that the capitalization rate must have been falling, while Herdt and Cochrane wrote that income gains were merely "expected" increases which vanished when capitalized. We can now set aside these erroneous interpretations and appreciate anew the analyses of rising asset earnings. Similar studies of the past decade are needed to provide information about the relative importance and probable trends of factors more recently responsible for an increase in real asset earnings. Again, difficulties posed for time-series analysis by the severe earnings cycle might require such work to be couched in terms of a comparison of, say, 1970–71 with 1978–79.

Policy implications of the new insights also need to be developed, both private and public. From 1954 to 1979, the total real rate of return to farm assets averaged about 8%, providing a rough estimate of the average real discount rate, or required rate of return, of farmland purchasers. If no real earnings growth were expected, farm real estate would sell at about 12.5 times earnings, to yield the required 8%. It is selling at double that multiple, yielding only 4%, and buyers implicitly expect that earnings will continue to rise at a long-term annual rate of 4%. They assume any risk of reduction in growth rate would lead to a capital loss as the land market became aware of it, while increase in the growth rate would give them a windfall gain. We need assessments of the nature of this risk, particularly by nonoperator investors who are increasingly encouraged to consider initial farm real estate purchases.

Perhaps public farm policy is not now as instrumental in maintaining asset earnings growth as earlier studies indicated, but the combined effect of farm programs such as storage loans, deficiency payments, disaster assistance, and export promotion may still be considerable. To the extent that these programs cause the earnings growth rate to be higher than it would otherwise be, they simultaneously increase the real price of farm output and reduce the rate of current earnings to assets, compared with levels that otherwise would have prevailed. The first effect is financially harmful to the general public; the second is not welcomed by farmers. It appears that both groups would benefit from a move to lower farm earnings growth, but in reality the process of so doing would be painful for farmers and farm landlords. In the short run, the rate of current earnings would first decline, because the response of asset values probably would lag the earnings change; then, when asset values did adjust, farm owners would experience capital losses. One could conclude easily that our political institutions would not care to undergo this experience. Perhaps our policy analysts can devise a path to lower earnings growth that will be tolerable to asset owners who have paid in advance for the higher growth rate.

Economic conditions and trends may be moving farm policy in this direction in spite of the inherent dilemma. Some government contributions to maintaining a high real growth rate of farm asset earnings are more acceptable to the public than others. First, policies helping real earnings to grow at a given rate in one sector are more easily accepted or tolerated if real economic growth in general equals or exceeds that rate. Otherwise, the resulting relative transfer of real wealth to the assisted sector requires more justification as a net contribution to the general welfare. Next, it is likely that such transfers are more easily tolerated if the underlying earnings growth results mainly from cost-reducing productivity gains rather than from increases in the real price of the sector's output. Finally, wealth transfers are more tolerable if the assisted economic units are relatively small and/or poor, or are so perceived.

The first two conditions appear to have turned against agriculture during the past decade. General economic growth slowed, and farm earnings growth became more dependent on real increases in output prices. The third condition is now also coming into play. Nearly fifty years of compounded growth in real wealth, abetted by consolidation of units and recently by reduction in estate taxes, have made many farm families rich from the perspective of the general public. There may be a significant risk of reduced government assistance for agriculture, or the aid may shift toward more subtle forms such as export promotion. Studies of these matters from our new analytical perspective should be interesting.

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Economic Welfare and Food Safety Regulation: The Case of Mechanically Deboned Meat: Comment

J. Bruce Bullock and Clement E. Ward

In a recent *Journal* article, McNiel estimated the welfare effects of USDA regulations governing the production and use of mechanically deboned meat (MDM). McNiel estimated a set of monthly supply and demand parameters to calculate the social costs of regulations. He then calculated the social cost of regulations that limit the output of MDM to 20% of processed meats, excluding ground meat, instead of all MDM economically recoverable by existing technology.

Two problems with the McNiel analysis invalidate his estimates of social costs. First, the data series used to estimate the demand and supply parameters is inappropriate. Second, the regulations limiting MDM usage will not become a constraint on total MDM production and will not generate social costs.

MDM Regulations

Three regulations affect the production and use of MDM from beef and pork carcasses:

(*a*) Amount of MDM in final product: MDM can make up no more than 20% of the total meat portion of a finished product. MDM is prohibited in ground beef and a few other products.

(*b*) Final product labeling requirements: a product containing MDM must contain a statement on the label which says "mechanically processed (species) product" in letters at least half the size of the product name. The label also must state, "contains up to _____% of powdered bone." This must be no less than one-fourth the size of the product name.

(*c*) MDM protein, fat, and calcium content: MDM can contain no more than 30% fat, 0.75% calcium, and no less than 14% protein.

Each of these has a different potential impact on the production and social costs of MDM.

McNiel's Analysis

McNiel notes that beef and pork are consumed either as table cuts or as processed meats. MDM is a potential ingredient in processed meats. Thus, for analysis it is desirable to partition the demand for beef and pork into that for table cuts and that for processed meats. Unfortunately, monthly data do not report the mix of table cuts and processed meats consumed.

To solve this problem, McNiel disaggregated total beef and pork consumption into "two components, table cuts and processed meats, using share estimates obtained from USDA consumption surveys which were consistent with the market shares used in constructing the price series" (McNiel, p. 4). Thus, the following relationship exists in the McNiel consumption data for both beef and pork:

$$QTM = \alpha MC,$$
$$QPM = (1 - \alpha)MC;$$

hence,

$$QPM = \left(\frac{1-\alpha}{\alpha}\right)QTM,$$

where QTM is quantity of table meat consumed, QPM is quantity of processed meat consumed, MC is $QTM + QPM$, and $0 < \alpha < 1$ is the table cut proportion of total consumption.

Consequently, the McNiel data maintain table cuts and processed meats in fixed proportions in all time periods. Based on the footnote to McNiel's table 2, the table cuts account for 60.8% and 77.6% of total beef and pork consumption, respectively. Thus $QPB = 0.64QTB$ and $QPP = 0.29QTP$ in McNiel's data series. These data cannot be used to estimate demand and supply parameters that purport to show the impact of changing proportions of table and processed meats. Thus, the elasticities in table 2 of McNiel's paper are not meaningful.

According to McNiel's analysis, the regulation limiting the MDM content of processed meat to no more than 20% would cause the total production of mechanically deboned beef (MDB) to be only about one-third of the economically feasible production level. Similarly, mechanically deboned pork production (MDP) would be only about one-sixth of the feasible level of production. However, it is physically impossible for the industry to produce enough MDB or MDP for the 20% restriction to become an effective constraint on total MDM production.

McNiel estimates that 39.2% of beef is consumed as processed meat. Agnew reports that ground beef accounts for about 57% of processed beef consump-

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tion. Thus, 16.9% of beef consumption is processed meat to which MDB could be added under current regulations. Field reports that the upper limit on MDB production is about 16 pounds per carcass. This would be a 2.7% increase in beef supplies assuming average 600-pound carcasses. Therefore, at a maximum, MDB could account for $\left(\frac{2.7}{16.9 + 2.7}\right) = 13.7\%$ of processed beef supplies, excluding ground beef. Similarly, MDP could account for no more than about 15% of processed pork production. Field also reports that the upper limit on MDP production is about 4 pounds per 137-pound carcass. This means that MDP will increase pork supplies by 2.9%. If 25% of processed pork is fresh ground (probably an overestimate), then MDP can account for at most $\frac{2.9}{16.8 + 2.9} =$ 15% of processed pork production. Consequently, the 20% regulation is not a restriction on total MDM production.

The inability of the McNiel model to assess correctly the impact of the MDM regulations indicates that it is improperly structured. This, plus inappropriate estimates of demand and supply elasticities, indicates that McNiel did not develop useful estimates of the welfare effects. Although McNiel did not develop valid estimates of the social costs, he addressed an important issue for consumers and the meat processing industry.

Economic Nature of Problem

Use of the MDM technology makes it possible to increase meat supplies without increasing the number or weight of animals slaughtered. The social costs of restricting the use of this technology are illustrated in figure 1.

The consumer demand for meats (composite of table cuts and processed meats) is represented by DD'. Without MDM technology, S_0 units of meat can be produced from the number of animals slaughtered during this period. Meat production can be expanded to S_m if MDM technology is used. The per unit cost of raw materials plus total costs of operating MDM equipment is represented by S_0H. The area $HABE$ represents the net social value of the MDM technology. The social cost of restricting the use of the technology is the portion of the social value of the technology that cannot be attained.

The 20% restriction will not become a constraint on total MDM output and hence will generate no social costs. However, it could be an effective constraint for some processed products. The product-labeling restriction is the current regulation that limits MDM production. Meat processors think that current labeling requirements project a negative image of their product to consumers. Therefore, they refuse to use MDM. Thus, all social costs of

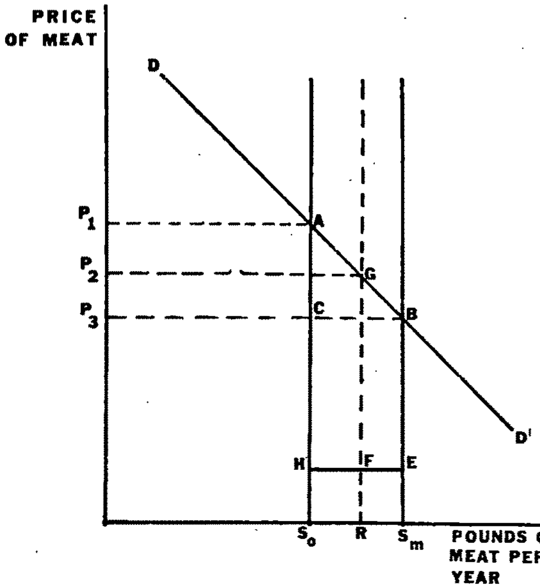

Figure 1. Illustration of impact of fat and protein content restrictions on the net economic value of MDM technology

current regulations ($HABE$ in figure 1) are attributable to the labeling requirements. "There is no basis for expecting that the long-term use of MDM would pose health hazards or that the long-term effects would be any different from other processed food products" (USGSA p. 26418). Consequently, there is no medical justification for this type of regulation. The success of a processed meat product in the marketplace depends on repeat purchases by satisfied customers. Competition will weed out products with too much MDM to satisfy consumers. Although this regulation does not generate social costs at present, it might in the future. Continuation of the 20% limit could preclude development of new products quite acceptable to consumers. Hence, the public interest would be served by removing this regulation.

The restriction on fat, protein, and calcium content of MDM is currently less important since labeling requirements reduce MDM production to zero. However, if the labeling restrictions were modified, the fat and protein regulations could become effective constraints on MDM production. MDM produced from fed cattle, upper grade cows, barrows, gilts, and sows either exceeds fat content restrictions or fails to meet minimum protein requirements. Thus, a considerable portion of the potential MDM supply will not be produced because of the fat and protein restriction even if the labeling requirements are removed. The potential impact of this restriction on MDM production likely will increase as boxed beef production expands, increasing the raw materials from fed cattle available for mechanical deboning.

If the labeling restrictions did not exist, fat content restrictions would restrict MDM output to S_cR rather than the economically feasible level S_oS_m (figure 1). Consequently, a portion of the potential MDM benefits would not be realized because of the restriction. The area *FGBE* represents the social cost associated with the fat and protein restrictions if the labeling regulations were removed. Estimates indicate that removal of the labeling restrictions would recover only about 30% of the social costs of the regulations unless the MDM fat and protein content restrictions also are removed (Bullock and Ward).

Current regulations establishing limits on MDM content in final products and maximum fat content of MDM provide the consumer no more protection than is already available through existing regulations and the economic realities of the marketplace. Moreover, these regulations impede the efficient use of resources and generate social costs without generating social benefits. Social welfare would be improved by eliminating them.

Potential Impacts of MDM Technology on Livestock Prices

The use of MDM technology both increases and decreases the value of beef and pork carcasses. The value of a carcass is increased because several pounds of edible MDM are recovered that otherwise would be sold as inedible byproducts. However, widespread use of MDM technology will increase total supply and, hence, reduce the price of meat, *ceteris paribus*. Thus, the net impact of MDM technology on carcass value (and therefore the price of livestock) depends on the relative magnitudes of these two impacts.

The impact on net farm value of 100 pounds of carcass of introducing MDM technology is identified by the following equation:

$$(1) \quad \Delta V = W_m{}^o(P'_m - P_m{}^o) + \Delta W(P'_m - P_b - C_d),$$

where ΔV is the change in net farm value per 100 pounds carcass weight (\$/cwt), $W_m{}^o$ is the pounds of meat marketed per 100 pounds of carcass if MDM technology is not used, ΔW is the additional pounds of carcass marketed as meat (not marketed as bone) per 100 pounds of carcass if MDM technology is used, $P_m{}^o$ is the price of meat that would exist if MDM technology is not used, P'_m is the price of meat as a result of using MDM technology to increase meat supplies, P_b is the price of bone (opportunity cost of marketing MDM is meat rather than bone),[1] and C_d is the cost of owning and operating MDM machinery (\$/pound of MDM).

[1] The price of raw materials is assumed to be the same whether or not MDM technology is used. Widespread use of MDM technology should increase P_b as the amount of this product sold is reduced. However, the magnitude of this impact would likely be quite small and is ignored for purposes of this discussion.

The first term of equation (1) measures the decrease in carcass value because of the reduced price of meat resulting from expanded supplies. The second term shows the net gain in value of ΔW pounds of MDM marketed as meat rather than bone. MDM production will be economically feasible if $(P'_m - P_b - C_d) > 0$, and there will be a net increase in social welfare from the use of MDM technology as illustrated in figure 1. However, depending on the value of ΔW, the introduction of MDM technology may result in a welfare transfer from producers to consumers.

The value of ΔV functions as a shifter of the derived demand for live animals. The determinants of the value of ΔV are identified by further examination of equation (1). By definition,

$$P'_m - P_m{}^o = \Delta P = \frac{\Delta W}{W_m{}^o} \cdot \eta \cdot P_m{}^o \leq 0,$$

where $\eta < 0$ is the price flexibility of meat with respect to the quantity of meat. Substituting this for $P'_m - P_n{}^o$ in the first term of equation (1) and multiplying the second term by $P_m{}^o/P_m{}^o$ results in

$$(2) \quad \Delta V = (\Delta W \cdot \eta \cdot P_m{}^o) + (\Delta W \cdot kP_m{}^o),$$

$$\Delta V = \Delta W \cdot P_m{}^o(\eta + k),$$

where $k = \dfrac{P'_m - P_b - C_d}{P_m{}^o}$ is the incremental net value of MDM expressed as a portion of $P_m{}^o$. This ratio has no particular economic interpretation. However, $1 > k > 0$ since $P'_m - P_m{}^o = < 0$, $P_b > 0$, and $C_d > 0$, and because $(P'_m - P_b - C_d) > 0$ if MDM technology is economically feasible.

If $\Delta V = 0$, the derived demand for livestock will not shift and the introduction of MDM technology would have a neutral impact on livestock producers. If $\Delta V > 0$, the derived demand for livestock will shift to the right and generate higher livestock prices, *ceteris paribus*. However, if $\Delta V < 0$, the derived demand for livestock will shift to the left and generate lower livestock prices.

Production of mechanically deboned beef and pork are both technologically and economically feasible (Bullock and Ward). Thus, any relaxation of MDM regulations will expand meat supplies, reduce meat prices, and expand social welfare. However, if $|\eta| > 1$, as most published estimates indicate, the widespread use of MDM technology will result in some amount of welfare transfer from producers to consumers.

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Economic Welfare and Food Safety Regulation: The Case of Mechanically Deboned Meat: Reply

Douglas W. McNiel

As Bullock and Ward point out in their "Comment," there are three major types of regulations which may presently be constraining MDM production and use—ingredient standards, use limitations, and labeling requirements. Bullock and Ward attempt to analyze and evaluate the separate economic effects of each type of regulation so that we may better understand the benefits and costs associated with various alternative regulations. Unfortunately, both the theoretical and empirical basis of their analysis have such serious deficiencies that only limited progress is made toward this objective.

Supply-Side Constraints

Regulations establishing ingredient standards and use limitations for MDM are primarily supply-side constraints. The correct methodology for analyzing such supply-side regulatory constraints is presented in my original work (McNiel). Bullock and Ward have attempted to improve upon this analysis with more detailed estimates of the effects of each type of regulation on the supply of (processed) meat . . . more on this later.

Demand-Side Constraints

While Bullock and Ward indicate that these supply-side regulations could become a constraint in the future, they argue that "all social costs of current regulations . . . are attributable to the labeling requirements." The impact of the labeling requirements for products containing MDM was not analyzed in my original work. Since most of the controversy over MDM regulation centers on labeling, additional analysis would be useful. However, evaluation of the labeling regulations requires a more complex methodology, not found in Bullock and Ward's analysis. The methodology they employ to evaluate this demand-side constraint does not differ from the methodology employed to evaluate the supply-side constraints. Unfortunately, the supply-side methodology alone is not appropriate for this extension nor adequate to support their argument.

Labeling regulations for products containing MDM have inherent demand-side implications which Bullock and Ward do not take into account when analyzing their attendant welfare effects. To attribute the entire welfare loss from MDM regulation solely to the labeling requirements, one must assume that (*a*) consumers with perfect information would regard processed meats containing MDM as homogenous with other processed meat products not containing MDM, and (*b*) currently required labels mislead consumers to "incorrectly" perceive products containing MDM so negatively that they cannot be marketed profitably. These assumptions strike at the heart of the MDM controversy. They are critical to Bullock and Ward's analysis, but no evidence of their validity is offered.[1]

The essence of Bullock and Ward's argument (made even more explicitly in their Oklahoma Agricultural Experiment Station research report) is that if consumers are not informed of the presence of MDM, processors could sell an additional S_oS_m units of meat at price P_3 (Bullock and Ward, "Comment," fig. 1). Yet Bullock and Ward also acknowledge that if consumers are made aware of the presence of MDM by current labeling requirements, consumers will no longer be willing to pay a price sufficient to bring forth this additional production. Demand curve *DD′* no longer reflects consumers' willingness to pay. Despite this, Bullock and Ward proceed to calculate the welfare loss from the foregone production using demand curve *DD′*. This error is compounded by the fact that in Bullock and Ward's calculations, the prices (P_3 in fig. 1) and elasticities used in valuing the foregone production are for table cuts and processed meats combined.[2] This leads to further overstatement of the value of the additional production since MDM will be marketed only in processed meat products which will sell at significantly lower prices than those used by Bullock and Ward.

Because their analysis is not focused on the rele-

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[1] The American Meat Institute has been collecting information on consumer reaction to the existing labels that seems to support the second assumption.

[2] In the Oklahoma Agricultural Experiment Station research report, Bullock and Ward calculate the potential economic value to society from mechanical deboning of beef as follows: the cost of producing mechanically deboned beef is 40¢ per pound; without the present labeling requirements, producers would be able to market the mechanically deboned beef for $2.23 per pound (the annual average retail price for beef); therefore, the loss to society is $1.83 per pound of foregone production. A similar argument is made for mechanically deboned pork.

vant market and does not address the issue of consumers' willingness to pay, Bullock and Ward do not provide a valid methodology for measuring the welfare effects of MDM labeling requirements. Consumer groups might use their calculations (Bullock and Ward) as a measure of the potential ripoff of consumers if the labeling requirements are changed. These calculations also might be interpreted as the maximum amount meat processors should be willing to spend (for consulting studies, legal services, political contributions, etc.) to alter the present regulatory regime or for marketing programs to convince consumers that MDM is not an undesirable ingredient.

A Demand-Side Methodology

While Bullock and Ward's analysis is inappropriate, their argument that all social costs of regulating MDM are attributable to the labeling requirements may be correct. Whether the labeling requirements result in welfare losses or gains depends upon whether these labels lead consumers to commit errors of omission or errors of commission and the size of any such errors relative to the size of the potential increase in the supply of processed meats.[3]

An error of commission occurs when consumers erroneously overestimate the quality and/or safety of a good. In figure 1, let *d'd'* represent the "correct" demand curve for processed meats containing MDM when consumers have full information (at least partially conveyed by distinguishing labels). Without labeling information regarding the presence of MDM, the "incorrect" consumer demand curve would be *dd*. Uninformed consumers would buy *oq* units at price *p*. Informed consumers would purchase only *oq'* units at this price. Under these circumstances, the labeling requirements prevent consumers from incurring a welfare loss represented by area *efg*—the excess of the additional amount consumers would spend (*q'efq*) over the amount of additional benefit they would receive (*q'egq*). This is the analytical basis of the argument advanced by the consumer groups who have raised the question of MDM use leading to economic adulteration. To ensure against this possibility, consumer groups have gone to court and lobbied extensively to obtain the current labeling requirements.

An error of omission occurs when consumers buy less than they would with full knowledge. Meat processors and their trade associations argue that this is a more accurate characterization of the present situation. Referring again to figure 1, let *dd* now represent the "correct" demand for processed meats containing MDM when consumers have full

[3] These terms apparently were coined by Douglas F. Greer in explaining the theoretical and empirical work of Darby and Karni, Peltzman, and McGuire, Nelson, and Spavins.

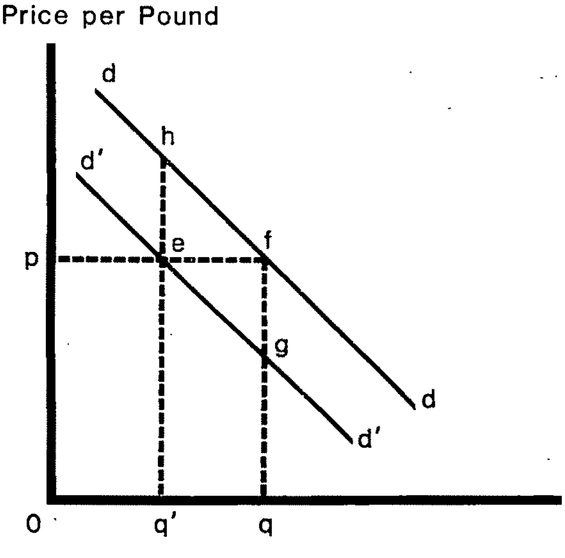

Figure 1. Welfare effects of labeling requirements

information. If the prescribed labeling requirements mislead consumers to undervalue products containing MDM *d'd'* now represents consumers' actual but "incorrect" demand curve. While consumers ought to purchase quantity *oq* at price *p*, because of misinformation (created by, or at least not corrected by, the required product labels) they purchase only quantity *oq'* at this price. Correction of this error would cost consumers an additional *q'efq*, but the added benefit would be *q'hfq*. The difference, area *efh*, represents the net gain to consumers from correcting this error. Correction might be achieved by eliminating the misleading information from the required labels or through information programs to convince consumers that the negative perceptions created by existing labels are unfounded.

Methodologically, if there is a social cost associated with the labeling requirements interfering with consumer sovereignty, it must be analyzed from the viewpoint that the required labels mislead consumers or cause them to behave differently than if they had perfect information about MDM (including its comparative nutritional value and any health and safety risks associated with its use). Consumer groups argue that the present labels provide the information necessary for consumers to express their preferences in the market. If this is true and, on the basis of this information, consumers elect not to buy products containing MDM, then there is no social cost associated with the labeling requirements. Valuing the additional pounds of MDM at a price consumers have demonstrated an unwillingness to pay violates one of the fundamental tenets of applied welfare analysis (Harberger).

Acceptance of Bullock and Ward's argument that the labeling requirements are currently responsible for all social costs of MDM regulation necessitates acceptance of the two assumptions mentioned in the previous section. In this case, p (figure 1) represents the equilibrium price at which products containing MDM would be sold when consumers have full information, and the size of the error of omission caused by the misleading labels, $q'q$, is equal to the potential increase in supply (S_oS_m in Bullock and Ward's fig. 1).

Even if the two assumptions are accepted, the appropriate retail prices and demand elasticities for valuing the increased potential production are not those applying to the entire beef or pork market, but rather those applying only to the processed meat products segment of these markets where at least some semblance of product homogeneity can be assumed after MDM is added. Until the demand-side effects of the labeling requirements are estimated empirically and analyzed in conjunction with the supply-side effects, Bullock and Ward's argument cannot be accepted.

Supply Shifts

Returning to the supply side constraints, there are at least two fallacies in Bullock and Ward's attempt to demonstrate that the 20% use limitation on MDM cannot be constraining.[4] First, the 600-pound carcass in the example will only yield about 444 pounds of salable retail meat (table and processed). Utilization of the mechanical deboning technology does not affect carcass weight, but rather allows meat processors to recover additional pounds of salable retail meat from the same carcass weight. Applying the rest of Bullock and Ward's assumptions yields a 3.6% potential increase in the retail supply of beef and a potential increase in the supply of processed beef of 17.56%. Second, the figure quoted on the ground beef share of the processed beef market (57%) is also for the carcass weight level, not the retail consumption level. This share was computed on the basis of certain assumptions from the production side about the disposition of various types of carcasses—not on the basis of consumption data. These assumptions and the conversion factors used result in this figure understating the share of ground beef at retail. Consumption surveys indicate that ground beef may account for as much as 80% of the processed beef market as defined in my work. When both of these modifications are made to Bullock and Ward's example, the potential increase in the retail supply of processed beef becomes almost 33%, which means that the 20%-use limitation may be constraining. Similar fallacies exist in Bullock and Ward's calculations to show that the 20%-use limitation cannot be constraining for mechanically deboned pork.

Livestock Prices

The impact of the mechanical deboning technology on the derived demand for livestock, an input used in the joint production of many different edible and inedible products, is an area where further analysis is warranted. In equation (1), Bullock and Ward examine this impact. This equation is meant to reflect the net change in incremental revenues and costs of all meat processors when mechanical deboning is adopted widely. This equation measures the change in economic welfare of meat processors only if supply is assumed to be perfectly inelastic. Bullock and Ward's initial interpretation of the equation is that "depending on the value of ΔW, the introduction of MDM technology may result in a welfare transfer from producers to consumers." In the final paragraph they conclude that "if $|\eta| > 1$ as most published estimates indicate, the widespread use of MDM technology will result in some amount of welfare transfer from producers to consumers."

The transfer of welfare from processors to consumers, area P_1ACP_3 in Bullock and Ward's figure 1, was never in doubt. The question is whether processors are net gainers or losers (i.e., the size of area P_1ACP_3, which is a transfer from processors to consumers, in relation to area $BCHE$, which is the gain to producers from reallocating livestock inputs from lower-valued inedible uses to higher-valued edible uses). Clearly, if $|\eta| > 1$, $|P_1ACP_3| > |BCS_oS_m| > |BCHE|$, and therefore, the net receipts of processors will fall implying a reduction in the derived demand for livestock.

Unfortunately, this analysis is likely to give misleading results because of its level of aggregation. The first term in equation (1) probably overstates the revenue loss to producers because the price change is applied not only to the incremental units of production, but across the entire meat market. In practice, use of MDM is unlikely to affect significantly the prices of table meats or even processed meats in which it is not included. To the extent that the processors are successful in segmenting their markets and limiting lower prices primarily to the new products produced with MDM, the technology is likely to increase processors' net revenues and lead to an increase in the derived demand for livestock.

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[4] The degree of constraint imposed by the 20% use limitation is overstated in table 4 (McNiel). Rather than indicating a 70%–80% difference from the changes in prices, quantities, and economic welfare associated with free market use of MDM, this regulation should be associated with differences of roughly 30%.

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Economic Trade-Offs and the North Carolina Shrimp Fishery: Comment

Ronald N. Johnson

In a recent *Journal* article, Waters, Easley, and Danielson (WED) offered calculations purporting to show the economic trade-offs of fishery regulation designed to reduce the discard of juvenile pink shrimp caught incidentally by fishermen harvesting brown shrimp. Reducing the cull of juvenile pink shrimp by seasonal closure or prohibiting night shrimping implies that the mature pink shrimp catch will be augmented later in the season. WED argue that such regulations would reduce the brown shrimp harvest. Consequently, an economic trade-off arises. Although WED conclude that the incidental catch and discard problem are not severe enough at this time to warrant new regulations to protect juvenile pink shrimp, they have ignored both the common property aspects of the fishery and the response of fishing effort to the potential increase in yields.

Following the model of Gordon and Scott (1955), assume that the total cost of fishing is a linear function of fishing effort. Further assume, as do WED (p. 126), that the demand for shrimp harvested in North Carolina waters is perfectly elastic. For shrimp, the revenue/yield curve can be assumed concave in the relevant range, with a positive first derivative. Under common property access, the Gordon and Scott model predicts that entry will take place until all rents are dissipated; that is, average revenue per unit of fishing effort will equal average cost. If the yield of pink shrimp were increased by allowing more juveniles to reach maturity, the revenue/yield function would shift upward and effort would increase. Once again, total revenue would equal total costs. The economic benefits from enhancement of the pink shrimp fishery via regulation are, in this case, equal to zero. However, in the WED formulation the calculated gross benefits to the pink shrimp fishery are positive. The reason for this is that they treated effort as exogenous. WED's equation (9) (p. 126) assumes no adjustment of fishing effort as yield increases. They essentially ignored the common property aspects of the fishery by not incorporating an effort response function into their model.

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In the real world, returns to fishery enhancement may not be zero even in an open access fishery. First, if demand is not perfectly elastic, there will be gains in consumer surplus from a larger net catch. Second, fishermen are not identical, and their supply to the industry is not infinitely elastic. Accordingly, rents may not be totally dissipated in an open-access fishery except for the marginal entrant. Third, there are likely to be lags in response to an enhancement project. Thus, benefits of enhancement may be positive over the short run even when the long-run effort supply function is perfectly elastic. Much recent discussion of fishery regulation concerns the response of effort to changes in property rights and regulations (Scott 1979 and Wilen). Limited entry, gear restrictions, and seasonal closures, for example, affect the amount of effort supplied since each fisherman will adjust at the relevant margins. To ignore supply response by individual fishermen in an open-access fishery, or even a regulated one, implies either that the harvesting costs do not matter and/or that effort is somehow exogenously determined. Estimates of economic trade-offs that ignore fishing effort changes due to regulation are primarily biological measures. They are likely to overstate the economic benefits.

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Economic Trade-Offs and the North Carolina Shrimp Fishery: Reply

James R. Waters, J. E. Easley, Jr., and Leon E. Danielson

In his comment in this issue on our recent *Journal* article (Waters, Easley, Danielson), Johnson misses the point. We examine the short-run dynamics involved in potential payoff to new regulations. We did not find sufficient short-run net benefits to warrant a policy; hence, we did not look at the long-run equilibrium question of how to preserve those rents. It makes no sense to pursue a problem that is not there.

The reader can quickly verify this by glancing at table 3 in our original article (p. 129). Presented in that table are thirteen sample observations on the discard rate taken between 1970 and 1975. Only one of these rates even approached our estimated break-even discard rates (rates above break-even would imply positive net benefits). We then conclude that, "it does not appear that the incidental catch and discard phenomenon is severe enough under normal conditions to warrant the adoption of policies designed to protect juvenile pink shrimp."

Had we found potential gains (even in most years) from a discard abatement policy, then the question of rent dissipation through entry to the fishery would have been relevant. However, this was not the case and we did not think it necessary to address the matter in the article.

Johnson's charge that we ignored the common property nature of the fishery is curious, given that the study was largely motivated by this feature. We explicitly state (p. 124): "Communal ownership distorts the choice between present and future income because individual fishermen do not consider foregone future income in their cost calculations." The reason, of course, is that shrimp are subject to capture by any fisherman, not just the ones who might forego earlier catch. That is, they are a common property resource. The basic analysis examines policy-induced trade-offs of income streams over time. The absence of an effort response function in our model in no way suggests the common property problem was ignored; it merely reflects an emphasis on the dynamic aspect of the fishery in the short run.

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Projected Replacement Needs for Agricultural Economists: Comment

R. A. Schrimper

In the August 1980 issue of this *Journal*, Schotzko reported that the number of Ph.D.s in agricultural economics required to offset anticipated retirements and deaths would increase during the next decade. This finding is in contrast to recent concerns about "overproduction and overeducation" in the United States, considering the rapid expansion of graduate enrollments in most fields (Cartter, Freeman). Implications of growth in the number of Ph.D.s in agricultural economics during the 1970s were noted by Helmberger. Boddy warned, however, that "the scare talk about the current and prospective general 'Ph.D. glut' is greatly overdrawn. . . . In economics and agricultural economics the prospects are far less discouraging than in most other fields" (p. 724).

The primary purpose of this comment is to note some problems with Schotzko's analysis. A second purpose is to discuss some changes in the characteristics and aggregate number of Ph.D.s granted in agricultural economics in the United States during the last two decades.

Shortcomings in Schotzko's Analysis

One problem with Schotzko's estimates of replacement needs is that only those receiving Ph.D.s after 1950 were taken into account in calculating age distributions. Anyone working in 1975 or after who received a Ph.D. prior to 1951 was not considered in Schotzko's age distribution, table 4 (p. 527). This is probably not important for age distributions in 1985 and later. In 1975, however, some of those who received a Ph.D. prior to 1951 would still have been active professionally, even though more than fifty years of age. This would influence the estimated number of retirements and deaths between 1975 and 1985. Omission of this group is likely to have biased downward Schotzko's estimated replacement needs, at least for the initial part of the period considered.

A second problem with Schotzko's analysis involves calculation of a non-reporting adjustment factor. This factor is defined as the ratio of all U.S. degree recipients for the years 1951–66, inclusive, to U.S. degree holders listed in the 1966 handbook. A question raised by this definition is how data for 1951–54 were handled since U.S. and foreign citizenship was not differentiated for these years, table 2 (p. 526). In correspondence, Schotzko indicated that all degree recipients in 1951–54 were assumed to be U.S. citizens. This assumption is troublesome because for the first couple of years when data permitted a separation by citizenship, nearly 20% of all degree recipients were classified as foreign. Assuming that all degrees were awarded to U.S. citizens for 25% of the years used in estimating the adjustment coefficient undoubtedly results in an upward bias. A lower coefficient value would have affected the age distributions in table 4 nonsymmetrically. The older age categories would have been most affected by this adjustment, causing some upward bias of estimated replacement needs. It is not clear that this error would offset the previous downward bias since their respective magnitudes are not known.

Another issue is the nonsystematic underestimation of total Ph.D. output, table 2. The problem is that the degree recipient list in the May *AJAE* can be quite incomplete. For example, if one considers 1968 degree recipients, it is necessary to consider not only the list in the May 1969 issue but also lists in the August 1969, November 1969, and May 1970 issues to get a full accounting. Even then, several gaps exist.

A more complete tabulation of Ph.D. degrees in agricultural economics awarded in 1961–63, 1968–70, and 1975–77 was obtained by the author for another study (Schrimper) by contacting department heads, graduate coordinators, or others at institutions not included in the *AJAE* lists for those years.[1] This data is summarized for those three periods in table 1. The data for 1968 indicates that the number of Ph.D.s was 181, instead of 126 as reported by Schotzko. Similar comparisons for 1969 and 1970 suggest Schotzko's data underestimate total degrees by 25% and 15%, respectively. The downward bias in Schotzko's series appears to be 10% to 20% for 1975–77. These nonsystematic biases would affect Schotzko's age distributions in his table 4. Consequently, the net effect on replacement needs is not obvious.

Schotzko indicates that underreporting in May

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The author is grateful to many colleagues for comments and suggested editorial improvements in earlier drafts of this manuscript.

[1] This compilation was restricted to institutions which usually would have been included in the *AJAE* lists. It does not include some of the top twenty institutions, identified by Spellman and Gabriel, having students between 1940–74 with dissertation interests in agriculture. These were Columbia, New York University, Pennsylvania, MIT, University of Texas, and Yale.

Table 1. Number of Ph.D. Degrees in Agricultural Economics

Time Period and Region[a]	Student Classification: Domestic	Foreign	Total Number of Degrees	Number of Institutions	Average No. of Degrees per Institution per Year
1961–63					
Northeast	23	8	31	4	2.6
North Central	162	57	219	10	7.3
South	50	4	54	7	2.6
West	36	5	41	5	2.7
Total	271	74	345	26	4.4
1968–70					
Northeast	57	33	92[b]	4	7.7
North Central	187	97	285[c]	11	8.6
South	99	17	120[d]	10	4.0
West	53	40	94[c]	7	4.5
Total	396	187	591	32	6.2
1975–77					
Northeast	36	23	59	5	3.9
North Central	113	97	211[c]	11	6.4
South	70	32	102	11	3.1
West	53	54	107	8	4.5
Total	272	206	479	34	4.6

Note: Data for Canadian institutions, Harvard, and South Dakota, which appeared in the *AJAE*, were excluded. The latter two schools each reported one degree during the nine years considered.
[a] Regions were defined consistent with the Census definitions except Delaware and Maryland were included in the Northeast, and Hawaii was included in the West.
[b] Includes two unclassified students.
[c] Includes one unclassified student.
[d] Includes four unclassified students.

issues of the *AJAE* did not seem to be serious based on comparisons with aggregate data of the U.S. Office of Education. Schotzko's numbers, however, are generally lower than values reported by Helmberger, although the two data sets are not directly comparable; one is reported in calendar years and the other in academic years. One problem with Office of Education data is the multiplicity of codes. For example, in some years these data include separate Ph.D. fields in agricultural business, agricultural and farm management, natural resource management, and agricultural economics. Furthermore, the number of agricultural economics degrees recorded by the U.S. Office of Education does not necessarily include economics degrees with agriculturally oriented dissertations granted by some departments regularly listed in the *AJAE*. Use of *AJAE* lists avoids an explicit definition of what agricultural economics encompasses. The procedure implicitly reflects whatever concept individual departments use to identify degree recipients for the *AJAE*.

Changes in Total Degrees over Time

The more complete tabulation indicates the same secular pattern of change as Schotzko's data. That is, output increased from an average of 115 per year in the early 1960s to just under 200 per year in the late 1960s. Then it declined to about 160 per year during 1975–77 (table 1).

The output peak probably occurred shortly after 1968–70, according to Schotzko's data. The total number of Ph.D.s apparently exceeded 200 per year a couple of times during the early 1970s before declining sharply in the mid-1970s. Thus, after an expansion of over 75% from the early 1960s, total Ph.D. output declined by approximately 20% between 1968–70 and 1975–77.

Despite the decline during the 1970s, the total number of Ph.D.s awarded in 1975–77 was approximately 40% larger than during 1961–63. The sharp decline in the 1970s contrasts with the expansion projected by Helmberger and demonstrates the hazards of extrapolating trends. Adjusting published data to account for nonreporting institutions suggests an average of slightly under 175 Ph.D. degrees per year for 1978 and 1979.[2] Thus, the sharp reduction of the early 70s may have ended.

[2] Estimates of 185 for 1978 and 163 for 1979 assume that the total output of nonreporting institutions changed from 1975–77 by the same proportion as that of reporting institutions.

Changes in Composition of Ph.D. Degrees

Practically all of the increase in total Ph.D.s in agricultural economics between 1961–63 and 1975–77 was foreign students.[3] About the same number of domestic students were receiving Ph.D.s in the late 1970s as in the early 1960s. Foreign students increased from 21% to approximately 43% of Ph.D.s awarded for the years under examination. These proportions are consistent with those of Schotzko. Most of the foreign student increase was from Asia, Central America, and South America.

The number of foreign students increased slightly between 1968–70 and 1975–77 in the presence of an overall decline in total degrees. This increase was substantially below the growth experienced between 1961–63 and 1968–70.

Geographical and Institutional Output Characteristics

Universities in the North Central region continue to account for most of the Ph.D. degrees awarded in agricultural economics, although that region's share has declined from 63% to 44%. Since the early 1960s, the relative shares for the South and West have continually increased. The Northeast share increased substantially between 1961–63 and 1968–70 but then declined slightly between 1968–70 and 1975–77. Some of these changes reflect several new Ph.D. programs initiated during the period. Six institutions without any Ph.D.s during 1961–63 accounted for some degrees in 1968–70. Three additional institutions awarded degrees in 1975–77.[4]

The North Central region continues to award the largest number of Ph.D.s per institution per year. Except in the West, the average number of degrees per program declined between 1968–70 and 1975–77 as a consequence of the decline in total degrees and the expansion in number of institutions offering a Ph.D. Except in the North Central region, the average program size was larger in 1975–77 than in 1961–63.

Despite variation in the total number of degrees granted during the three periods, the set of institutions comprising the ten largest programs has been quite consistent, although individual rankings have fluctuated.[5] Berkeley, Cornell, Illinois, Iowa State, Michigan State, Ohio State, Purdue, and Wisconsin were in this set in each of the three periods. Minnesota was included twice and the following were included once: Davis, Chicago, North Carolina State, Oregon State, and Washington State. The institutions appearing most frequently in the top ten are very similar to those of the 1950s identified by Nichols.

The degree of concentration among institutions within the Ph.D. agricultural economics producing industry has decreased during the last two decades. In 1961–63, the ten largest programs accounted for 70% of all U.S. Ph.D. degrees in agricultural economics. In 1975–77, 55% were awarded by the eleven largest.[6] A similar trend was observed earlier by Nichols and is consistent with changes in general economics reported by Spellman and Gabriel, and Boddy. New Ph.D. programs initiated since the early 1960s accounted for approximately 17% of the total agricultural economics degrees awarded in 1975–77.

All but two of the thirty-five institutions included in table 1 are public institutions. Two private institutions, Chicago and Stanford, accounted for slightly over 4% of the total degrees in 1975–77 compared to 5.5% in 1961–63. This indicates continued dominance of public institutions in granting Ph.D.s in agricultural economics noted earlier by Nichols and Hathaway.

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[3] In order to tabulate the number of Ph.D.s granted to domestic and foreign students, prior academic training of each individual was used for classification purposes. Those who had a bachelor's degree from an institution outside the United States were classified as foreign students. A few individuals without bachelor degree information were considered to be foreign students if they received a master's degree outside the United States. This scheme led to a clear classification for all but nine students with missing undergraduate information. These nine individuals were not classified as either foreign or domestic students. As a result of this classification scheme, data in table 1 must be interpreted with caution.

[4] A new program at Utah State reported 4 and 7 graduates in 1978 and 1979, respectively.

[5] More detailed tabulations of data in table 1 for each university and information about sources and migration patterns of Ph.D. students are available in another report (Schrimper).

[6] Illinois and Oregon State tied for tenth spot in 1975–77.

Projected Replacement Needs for Agricultural Economists: Reply

Ralph T. Schotzko

Schrimper's comment suggests that some clarification of procedures is required. Three specific points are mentioned by Schrimper as being problematic. These problem areas are (*a*) exclusion of Ph.D. degree holders who received degrees prior to 1951; (*b*) the assumption regarding foreign recipients of U.S. Ph.D. degrees during 1951–54, inclusive; and, (*c*) the problem of under-reporting in the *AJAE*. Each will be addressed in sequence.

Schrimper's concern about the impact of pre-1951 recipients on the replacement estimates is unfounded. The 1966 *Handbook-Directory* provided the base data. All Ph.D. degree holders listed for whom year of birth information was available were included. The confusion appears to have been caused by the non-reporting inflation factor. The inflation was based on U.S. degree recipients for the period 1951–66, inclusive.

It is recognized that problems exist in using any *Handbook-Directory* for this type of analysis. However, as indicated in the original note, the 1966 *Handbook* appears to contain the largest percentage of U.S. degree recipients among the available alternatives.

In the original note, it was assumed that all Ph.D. degree recipients during the period 1951–54 were U.S. citizens. This assumption affects the size of the nonreporting inflation factor (N_0).

Schrimper argues that ignoring the foregn recipients from 25% of the years included in the inflation factor will cause a significant bias. He argues further for an assumption of 22% foreign recipients during the 1951–54.

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Changing the assumption about foreign recipients during 1951–54 affects both the numerator and the denominator of the inflation factor. The inflation factor will increase, decrease, or remain the same depending on the relative changes in the numerator and denominator.

Recalculating N_o assuming 25% foreign recipients during the period 1951–54, and, that they are listed in the 1966 *Handbook* in the same proportion as foreign recipients during 1955–66, changes the value of N_o from 1.37 to 1.34. The effect of this bias is shown in table 1, columns 1 and 4. Column 1 contains the attrition levels presented in table 4 of the original note. Column 4 of table 1 shows the effects of changing N_o from 1.37 to 1.34 and applying it to the original data. The new value of N_o reduces the number of vacancies caused by attrition by nine over the 15-year period. All of the reduction occurs during the 1980s, an average of less than one per year.

Schrimper's third point is valid for two reasons. During the late 1960s, degree recipients were listed throughout the year, not just in the May issues of *AJAE*. The degree recipients listed in the "off" issues were not included in the original note.

Columns 2 and 5 in table 1 contain the estimated attrition levels incorporating the lists of degree recipients from the non-May issues of the *AJAE*. Regardless of the assumption concerning N_o the impact is relatively small. Spreading the difference between either columns 1 and 2 (10 positions) or columns 4 and 5 (3 positions) over fifteen years shows the minor impact of the additional data.

The May listings were checked against *Handbook-Directory* information, wherever possible, to minimize incorrect year of degree informa-

Table 1. Alternate Estimates of Attrition Rates

	Number of Vacated Positions					
	N_o = 1.37			N_o = 1.34		
	Original Data	New Data	20% Adjustment	Original Data	New Data	20% Adjustment
1975–80	250	254	258	250	251	255
1980–85	299	300	307	294	294	300
1985–90	413	418	432	409	411	424
Total	962	972	997	953	956	979

tion. Checks for double listing of recipients were also made.

The problem of nonlisted recipients provides a classic example of the problems inherent with secondary data. No precise measure of the effect of nonlisted recipients is possible. However, by making two assumptions, it is possible to evaluate the sensitivity of the estimation procedure.

Assume: (*a*) that nonlisted recipients during 1967–75 are 20% of the listed recipients (Schrimper's survey indicates this to be a reasonable estimate), and (*b*) that the age distribution of the nonlisted recipients is the same as the listed recipients. The attrition levels in columns 3 and 6 of table 1 are based on these assumptions. Over the fifteen years, the average is less than two additional vacancies per year. However, over half of the increase occurs in the last five years.

In terms of impact, the problem of nonlisted recipients is most important. However, even a 20% increase in recipients increases attrition vacancies by only about 2.5%. The apparent robustness of the estimation procedure indicates that the interval of uncertainty suggested by Schrimper may be fairly narrow.

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Perfect Aggregation and Disaggregation of Complementarity Problems: Comment

Antonio Guccione

In a recent article in this *Journal*, Paris proposes new and interesting results on the aggregation of programming models. In particular, he claims to have weakened the perfect consolidation conditions suggested by Day for linear programs and by Oguchi and Guccione for quadratic programs, while retaining their formal framework. His claim is not completely valid. To illustrate, the aggregation of von Thünen's model is briefly considered as an example.

In his classic paper on consolidating linear programs, Day postulates a macromodel that is a complete miniaturization of the corresponding microsystems. The purpose is to construct a smaller model, easier to understand and manipulate than the underlying disaggregate ones. Thus, all the weighting functions relating microvariables (microparameters) and macrovariables (macroparameters) are defined prior to aggregation. In addition, the aggregation weights are economic constants, rather than arbitrary multipliers determined endogenously by the consolidation algorithm. Specifically, the consolidated net revenue vector is restricted to fixed convex combinations of the corresponding disaggregated vectors. This permits all the usual economic interpretations of the weights. That is, on a priori grounds, all microvectors may be equally weighted, some reference to scale introduced, or another economically relevant definition adopted. The resource macrovector is a simple sum of corresponding microvariables. The technological matrix is defined as a convex combination of microtechnologies. Again, the weights are fixed prior to aggregation, allowing a clear interpretation of the macroproblem. The aggregated primal and dual variables are similarly defined.

Consider Paris's claim that Day's aggregation conditions can be relaxed. It is easy to show that the two frameworks are different. In particular, Paris's macrotechnology $\mathbf{A}_0$ is not the same as Day's. Early in Paris's paper, the matrix $\mathbf{A}_0$ is assumed to be a linear combination of the microtechnologies. Later, the matrix of weights, $\mathbf{U}$, is replaced by the non-unique matrix $\mathbf{U}^*$, rendering $\mathbf{A}_0$ a purely formal construct. Because fewer constraints are now imposed on the consolidation algorithm, the solution conditions become less restrictive. If the aggregator $\mathbf{U}$ is not replaced by $\mathbf{U}^*$, and if the elements of $\mathbf{U}$ are properly defined, then the results are not essentially different from Day's.

Since the matrix $\mathbf{A}_0$ is constructed differently in the two approaches, the corresponding macrosystems have different interpretations. In fact, the precise meaning of Paris's macromodel is not always clear. Under some circumstances his algorithm may generate the same weights as Day's. Occasionally, the weights may be interpretable, *ex post,* in some other way. However, they are frequently uninterpretable. Paris (p. 684) tries to rationalize his aggregated technology in terms of "efficiency units," claiming that this interpretation is equivalent to Day's. Unfortunately, the notion of "efficiency units" is ambiguous, and may be meaningless. In any case, an *ex post* interpretation is not, logically, equivalent to an *ex ante* definition.

Similar comments can be made for the aggregation of quadratic programming models. Oguchi and Guccione prove the impossibility of miniaturization. Paris shows that consolidation with variable weights is possible.

The aggregation of von Thünen's model (summarized by Dunn) will illustrate the implications of different assumptions on the weights. Although the analysis is general, consider the location of two agricultural industries on a flat, undifferentiated plain, containing a single market point. These two industries are characterized by (a) fixed prices of the outputs [$p_0^{(1)}$ and $p_0^{(2)}$] and the non-land input (p_2); (b) production functions of the form

$$x_0^{(i)} = x_1^{(i)}/a_1^{(i)} = x_2^{(i)}/a_2^{(i)},\ a_1^{(i)},\ a_2^{(i)} > 0,$$

where $i = 1,2$, $x_0^{(i)}$, $x_1^{(i)}$, $x_2^{(i)}$ are, respectively, output, land, and non-land inputs of industry i; (c) transportation costs defined as

$$p_3^{(i)}\, x_3^{(i)}\, x_0^{(i)},$$

where $i = 1,2$, $p_3^{(i)}$ is the (given) cost of moving one ton of good i one mile, and where $x_3^{(i)}$ is the distance in miles from the market place; and (d) rent maximization. Under these assumptions the first industry will locate within a circle around the market. The second will locate in the complement of a larger circle around the market, provided that

$$[p_0^{(1)} - a_2^{(1)} p_2]/a_1^{(1)} > [p_0^{(2)} - a_2^{(2)} p_2]/a_1^{(2)}$$

$$[p_3^{(1)}/a_1^{(1)}] < [p_3^{(2)}/a_1^{(2)}].$$

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He wishes to thank W. J. Gillen and a careful referee for their helpful comments.

It is easy to compute the amount of land utilized and the output produced by each industry.

An aggregate model in which the two industries are collapsed into a single one is obtained as follows. The production function is written as

$$x_0 = x_1/a_1 = x_2/a_2,$$

where

$$a_i = \alpha_i^{(1)} a_i^{(1)} + \alpha_i^{(2)} a_i^{(2)}, \alpha_i^{(1)}, \alpha_i^{(2)} \geq 0, \alpha_i^{(1)} + \alpha_i^{(2)} = 1,$$

and $i = 1,2$. The micro and macro input variables are related by

$$x_i = x_i^{(1)} + x_i^{(2)},$$

where $i = 1,2$. Aggregated output, its price, and its transportation cost are given by

$$x_o = \beta^{(1)} x_0^{(1)} + \beta^{(2)} x_0^{(2)}, \beta^{(1)}, \beta^{(2)} \geq 0,$$

$$p_0 = \gamma^{(1)} p_0^{(1)} + \gamma^{(2)} p_0^{(2)}, \gamma^{(1)}, \gamma^{(2)} \geq 0,$$

$$p_3 = \delta^{(1)} p_3^{(1)} + \delta^{(2)} p_3^{(2)}, \delta^{(1)}, \delta^{(2)} \geq 0.$$

Probably the most natural definitions of these weights are

$$\alpha_i^{(1)} = \alpha_i^{(2)} = 1/2,$$

$$\beta^{(i)} = \bar{p}_0^{(i)} \bar{x}_0/(\bar{p}_0^{(1)} \bar{x}^{(1)} + \bar{p}_0^{(2)} \bar{x}_0^{(2)}),$$

$$\gamma^{(i)} = \bar{p}_0 \bar{x}_0^{(i)}/[\bar{p}_0^{(1)} \bar{x}_0^{(1)} + \bar{p}_0^{(2)} \bar{x}_0^{(2)}],$$

$$\delta^{(i)} = \beta^{(i)} [\bar{x}_0^{(i)}/\bar{x}_0],$$

where in each case $i = 1,2$, and the overbar refers to a base situation. The problem here is to identify conditions under which equal values of the variables x_1 and x_0 can be obtained solving the aggregated model directly or, alternatively, solving first the disaggregated model for $x_1^{(1)}$, $x_1^{(2)}$, $x_0^{(1)}$, $x_0^{(2)}$ and then consolidating them. To test when perfect aggregation of land is possible, consider the conditions under which the following unit rent functions will have the same solution for (maximum) distance from the market:

$$\{[p_0^{(2)} - a_2^{(2)} p_2]/a_1^{(2)}\} - [p_3^{(2)}/a_1^{(2)}] x_3^{(2)} = 0,$$

$$[(p_0 - a_2 p_2)/a_1] - (p_3/a_1) x_3 = 0.$$

Imposing $x_3 = x_3^{(2)}$, rearranging terms, and using the definitions of the macrovariables p_0, p_3, and a_2 produces the following equation:

$$(1) \quad \alpha_2^{(1)} p_2 p_3^{(2)} a_2^{(1)} - [\delta^{(1)} p_3^{(1)} + \delta^{(2)} p_3^{(2)} - \alpha_2^{(2)} p_3^{(2)}] p_2 a_2^{(2)} = [\gamma^{(1)} p_0^{(1)} + \gamma^{(2)} p_0^{(2)}] p_3^{(2)} - [\delta^{(1)} p_3^{(1)} + \delta^{(2)} p_3^{(2)}] p_0^{(2)}.$$

Notice that the variables $p_0^{(1)}$, $p_0^{(2)}$, $p_3^{(1)}$, $p_3^{(2)}$ are exogenous and that the multipliers $\alpha_2^{(1)}$, $\alpha_2^{(2)}$, $\gamma^{(1)}$, $\gamma^{(2)}$, $\delta^{(1)}$, $\delta^{(2)}$ must be treated as fixed for miniaturization. Thus it is impossible to choose values of the coefficients $a_2^{(1)}$ and $a_2^{(2)}$ which satisfy equation (1) for all possible patterns of the exogenous variables. However, land can be perfectly consolidated constraining the exogenous variables to satisfy equation (1). Consider aggregation over outputs. The definition of aggregate output and the production function imply the equation

$$x_1 = \beta^{(1)} [a_1/a_1^{(1)}] x_1^{(1)} + \beta^{(2)} [a_1/a_1^{(2)}] x_1^{(2)}.$$

For perfect aggregation, then, the following relations must be satisfied:

$$(2) \qquad \beta^{(1)} [a_1/a_1^{(1)}] = \beta^{(2)} [a_1/a_1^{(2)}] = 1.$$

In general, equation (2) will not hold because the constants $\beta^{(1)}$ and $\beta^{(2)}$ are exogenous to the consolidation scheme. In summary, miniaturization is possible under constraint for land, but it is impossible for outputs.

Consider, now, free-weights aggregation. Since the choice of values for the weights is open, equation (1) can be satisfied without any restriction on the prices. Similarly, the multipliers $\beta^{(1)}$ and $\beta^{(2)}$ can be selected to make relation (2) hold. However, if the exogenous variables change, the weights must be recomputed. Moreover, the meaning of the aggregates becomes obscure. For example, it is impossible to interpret the variables x_0, p_0, and p_3 in terms of Laspeyres indexes.

In conclusion, as in the case of regression models (see Tintner and Sonderman, and Fisher), we must distinguish between consolidation with fixed weights and consolidation with variable weights. The choice between these approaches depends on the goals pursued by the researcher. Complete interpretability of the aggregate model requires fixed weights. However, if interpretability of some subset of the macroparameters is not wanted, then the corresponding weights may be treated as variables, and aggregation becomes easier. Indeed, there seems to be a trade off between (*ex ante*) interpretability and the stringency of the corresponding consolidation conditions. It is illegitimate, therefore, to compare aggregation requirements which correspond to difference assumptions on the weights.

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Perfect Aggregation and Disaggregation of Complementarity Problems: Reply

Quirino Paris

Aggregation is an empirical problem. It arises when a researcher does not wish to or cannot handle the information specifying the microproblem under study. In either case, aggregation entails loss of information. In such circumstances, it seems plausible to search for procedures that minimize this loss.

Although seldom discussed in the literature, disaggregation is intimately related to the aggregation problem. After performing the desired analysis on the aggregate model, often there is the necessity of apportioning the implementation of the preferred macrosolution among distinct microagents.

If it were possible to find a one-to-one relation between the micro- and the macrospaces (the spaces of the disaggregate and consolidated problems, respectively), loss of information would occur neither in the aggregation nor in the disaggregation processes. However, because the microspace is much wider than the macro counterpart, only a portion of the information contained in it can be transferred to the macrospace (via aggregation) and back (via disaggregation). This is the reason for requiring aggregation under constrained consistency. In empirical problems, not all points in the microspace are of interest because they may be, de facto, either irrelevant or inaccessible. Accordingly, a researcher determines, problem by problem, the portion of the microspace that is relevant for his study. Under this careful reduction, it may be possible to establish a one-to-one correspondence between the micro and the macrospace. This is the essence of constrained consistency.

Information is transferred back and forth between the two spaces by means of aggregation and disaggregation operators (matrices). The more general these matrices, the larger the quantity of information that can be preserved in the aggregation and disaggregation processes. Conversely, the simpler the aggregation matrices, the greater the information loss. Matrices composed only by ones and zeros are the simplest aggregation operators, carrying the least amount of information.

A related aspect of the discussion is whether or not the aggregation problem should be "solved" once and for all (with a "solution" reputed valid for any empirical problem), or whether it should be reconsidered each time, in relation to the given empirical problem under study. It seems clear that by opting for Day's approach, Guccione wishes to "solve" the aggregation problem once and for all. Because this goal is very (too) ambitious, he is compelled (as was Day) to admit to consistent aggregation only very simplified and improbable microstructures such as those in which all firms have identical technologies and proportional constraint vectors.

If, on the other hand, a researcher really considers aggregation and disaggregation as empirical problems, he is contented to solve them case by case. Thus, aggregation matrices suitable for one problem will have different structure, numerical components, and meaning in another problem. To me, all this seems perfectly reasonable.

Does this mean that in my approach weights are variable, as repeatedly asserted by Guccione? No. The weights (the aggregation matrices) are fixed for any given empirical problem. In other words, for any set of fixed aggregation and disaggregation matrices as defined in my paper, only those microstructures that satisfy the conditions of the aggregation theorem will admit consistent aggregation. This point is clearly illustrated by the numerical example of tables 1 and 2 in the original paper. Using the same aggregation matrices presented in table 2 and defined a priori (as Guccione claims aggregation ought to be performed), three sets of revenue and constraint vectors (exogenous variables in Guccione's terminology) were selected to show consistent aggregation and disaggregation. Obviously, one could choose an infinite number of such vectors and perform consistent aggregation using the same weights, as long as these vectors satisfy the constrained consistency assumption.

Incidentally, that numerical example illustrates consistent aggregation of a quadratic programming problem. Together with another example specifically developed in the text, it should lay to rest the question raised by Oguchi and Guccione whether or not the dual variables in quadratic programming can be consistently aggregated.

Many assertions are enunciated by Guccione, few of which I can agree with. Most of the points raised in his comment were anticipated in my original paper. Five of Guccione's statements, however, deserve rebuttal. They relate to (*a*) the alleged difference between Day's framework and mine, (*b*) the economic interpretability of weights, (*c*) the interpretability of aggregate quantities, (*d*) the

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definition of aggregate technology, and (*e*) the example of a von Thünen economy.

(*a*) Day's framework is a special case of mine. This much is admitted also by Guccione. Only in this sense are they "different." I prefer to consider my suggestion as a generalization.

(*b*) Guccione limits the economic interpretability of weights to the set of numbers composed by ones and proportions. He refuses to recognize the usefulness of efficiency units. This is surprising. Not only did agricultural statisticians pioneer the use of efficiency units to obtain an aggregate measure of child, male, and female labor; but, more recently, efficiency units have become an important notion for measuring any input subject to technical progress. The alleged ambiguity of efficiency units can be reduced not by eliminating the units, but by their careful definition. They are certainly necessary in the aggregation of nonhomogenous resources.

(*c*) The interpretability of aggregate quantities seems to me more important than the economic interpretability of weights. In this regard, the framework I suggest should be irreproachable because every aggregate relation is defined exclusively in terms of the corresponding microrelations, and no problem of interpretability arises. This point is discussed and illustrated in detail in my paper.

(*d*) According to Guccione, an aggregate technology makes sense only if "defined as a convex combination of microtechnologies." This is clearly unnecessary. In aggregating input-output tables, for example, the consolidated technology is composed of the row and column sums of the microsectors' coefficients. He is also incorrect when writing that the matrix $\mathbf{A}_a$ in my paper is assumed to be a convex combination of microtechnologies. Such a matrix is defined throughout as $\mathbf{A}_a = W'AD$, where W and D are nonnegative aggregation operators. This expression is obviously not a convex combination of $\mathbf{A}$, the microtechnology.

(*e*) The von Thünen example merely indicates the need for aggregation under constrained consistency. Guccione asserts that "if the exogenous variables change, the weights must be recomputed." He then concludes that the weights in my paper are variable. I already pointed out that, in my approach, the aggregation matrices are fixed because one can change the exogenous variables without changing the weights.

Aggregation remains a largely unsolved empirical problem. Knowledge of the most general and flexible mathematical structure by which a researcher can define his model is a prerequisite for progress toward a solution. It is important to suggest that this solution should take into account the implied degrees of freedom problem. In general, it seems convenient to avoid that the specification of aggregation and the choice of weights more than exhaust the degrees of freedom, as in the von Thünen's example of Guccione. In most empirical problems, such a choice is possible under constrained consistency, while preserving the economic interpretability of both weights and aggregate relations. Guccione's comments may be evaluated within this context.

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Editor's Note

A correction is necessary in equation (5) on page 304 of the May 1981 issue of the *Journal.* This equation, in the "Reply" written by Mittelhammer and Young, should be as follows:

$$(5)\qquad 0 \le a \le 2\left[\frac{J+\eta}{1+\eta} - 2\right]/(T - K + 2).$$

Also, in the two lines below equation (5) on page 304, X'_{n+1} and X_{n+1} should be x'_{n+1} and x_{n+1}, respectively.

Books Reviewed

Downey, W. David, and John K. Trocke. ***Agribusiness Management.*** **New York: McGraw-Hill Book Co., 1981, x + 459 pp., price unknown.**

The book is written for those interested in an agribusiness career. The authors' stated purpose is to provide a textbook for a 1–3-term undergraduate course. It might also serve as a reference book for agribusiness managers in large and small firms.

The book is organized into five sections, which vary greatly in length and subject matter coverage. Part 1 addresses the role and organization of agriculture. Part 2 deals with financial management and control of the firm. Part 3 is devoted to agribusiness marketing. The next section, only 22 pages, deals with production processes for a firm. Part 5, also short, concerns managing human resources in business. An appendix to the book is designed to help individuals obtain jobs in agribusiness management. Last, the book contains a detailed glossary.

Overall, the book covers a broad subject rather well. However, the coverage of some specific subjects is spotty. For example, the two chapters on management of human resources are thorough and well done, but the chapters on economics touch on many important concepts without explaining why they are important.

Chapter 13 gives scanty coverage to the tools of decision making in marketing. Chapter 14 tells a prospective agribusiness firm employee what the sales profession is like, and Chapter 15 is a thorough description of the selling process.

Instructors whose courses involve economics, accounting, and finance generally find it hard to locate a textbook which fits their needs. Downey and Trocke no doubt will help many such instructors. Other instructors will find some chapters useful as specific references. Still others may find the book an acceptable text after they rearrange the order and coverage of some topics.

The potential value of this book as a reference is mixed. Some material may be too shallow to be of much reference value. Yet, other topics are treated thoroughly. The glossary can be quite helpful for those without recent formal training in this general area. The section on economics may cause problems for those not already well-versed in the subject. The statement, "In a perfectly competitive free market system, profits should not exist" (p. 81), may come as a shock. Moreover, the difference between an accountant's and an economist's view of profits is not well explained.

There are many good points in the way material is handled, and the book is well-written. The writing style is more like an informal conversation than a formal presentation. Each chapter begins with a detailed set of objectives and each is summarized concisely. Each chapter ends with a challenging set of discussion questions and a well-defined case problem. The preface indicates that an instructor's manual is available, but it was not available for this review.

Agricultural extension specialists in agribusiness management certainly should read the book. Sections of the book provide ready-made material for workshops and short courses. No doubt many will find the book a welcome addition to their shelves.

Travis D. Phillips and
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Forster, D. Lynn, and Bernard L. Erven. ***Foundations for Managing the Farm Business.*** **Columbus, Ohio: Grid Publishing Co., 1981, xii + 351 pp., $23.00.**

This is a textbook for introductory farm management courses. It is one of several new offerings in the field, after two decades of little innovation. The topics covered in *Foundations for Managing the Farm Business* are typical of other texts currently in print. It offers a bit more material on estate planning (a separate chapter), but a bit less than others on such topics as tax management, strategies for avoiding or managing risks, and miscellaneous records, such as maps and livestock and machinery records.

The strength of the book lies in the richness of detail and example that is provided throughout. The chapter on financial statements, for example, includes an example of each type of statement as it is introduced, followed by a complete set of annual statements for a hypothetical farm. The chapter on budgeting includes not only some examples of partial budgeting, but also eleven separate enterprise budgets for an array of crop and livestock activities. Institutional detail is not neglected, either, with a very nice graph of marginal tax rates for individuals and corporations, tables of federal estate and gift tax rates, and sample contracts for farm-leasing arrangements. The attention to detail is also reflected in the average of fourteen or so questions at the end of each chapter. These questions are relevant to the material and provide a good balance of recall and problem-oriented questions.

The layout of this text is not as refined as those of its competitors, and this detracts from the readability of the book, as does the writing style of the authors. The writing style is occasionally lively and usually straightforward, but generally tends to be laborious.

Treatments of some of the topics are particularly pleasing to this reviewer: the extended treatment of estate management, the frequent application of partial budgeting, and the frequent reference to opportunity costs (especially in evaluating "assets in place"). On the other hand, the treatment of several other topics is not so pleasing. The section on analyzing the farm business describes a number of financial ratios and efficiency ratios, but there is little explanation of how these ratios are to be used in analyzing the business. No standards of performance are offered, and the authors lamely conclude that common sense and good judgment are required to interpret such numbers. The capital budgeting chapter offers not a single comment on the phenomenon of inflation and how to deal with it in evaluating a capital investment decision. It is probably appropriate that the authors emphasize the net present value criterion here, but they offer no comparative evaluation of this criterion with other common criteria such as payback period or internal rate of return. On the question of choosing a discount rate for present value calculations, the authors recommend using the average rate of return on assets, which is an unfortunate departure from their otherwise persistent adherence to the principle of opportunity cost. Finally, the chapter on the difficult subject of labor management strikes this reviewer as being weak. It includes some helpful material on planning the labor calendar, on training, and on learning patterns. But the section on motivation relies heavily on McGregor's Theory X-Theory Y, Maselow's hierarchy of needs, and Herzberg's hygiene-motivational analysis of job satisfaction. Perhaps it is important for students to be aware of these points of view, but it seems doubtful that the material presented is sufficient to improve students' labor management skills. The text could well have included more material on the possibilities of profit-sharing arrangements, on the use of fringe benefits, and on issues in labor-capital substitution.

On balance, this book will certainly be of value to students and teachers of farm management. At $23, it is the most expensive of several available texts. Given its strengths and shortcomings in comparison with other texts, most instructors probably will wish to use it as a reference rather than as the primary text.

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Kay, Ronald D. ***Farm Management: Planning, Control and Implementation.*** **New York: McGraw-Hill Book Co., 1981, xiii + 370 pp., $17.95.**

This book, proposed as an introductory farm management text, discusses many traditional areas and emphasizes application of economic principles for analyzing practical problems and the use of budgeting techniques for planning and choosing among alternatives. In contrast to many earlier farm management texts, it places less emphasis on analyzing the details of specific types of farm decisions. The book contains no specialized chapters on crop and livestock management decisions and discusses superficially, if at all, such topics as rotations, soil conservation, livestock replacement decisions, feeding rations, and finishing weights of animals. The book is oriented more to the presentation of fundamental concepts, with less emphasis on rules of thumb and "seat of the pants" philosophy that has characterized many earlier farm management texts. The book has a relatively heavy emphasis on the financial aspects of farm decisions and, like several recent farm management books, contains several chapters traditionally considered to be the province of farm accounting and farm business analysis courses.

The book is organized around three basic functions of management: planning, control, and implementation. Nineteen chapters are divided into five units. Part 1 includes only one chapter and deals with the management function. Part 2 includes five chapters classified together under the title of planning. This section includes the basic concepts of marginal analysis and cost common to recent farm management texts. Coverage of relevant economic notions is relatively complete but the depth of coverage may be insufficient for students with little or no economic background. Instructors may need to supplement these chapters with more illustrations and perhaps supplementary readings. Three chapters of part 2 are devoted to the budgeting processes: enterprise, partial, whole farm, and cash-flow. The sections on crop and livestock enterprise budgets are particularly well done, perhaps the best discussion of this topic available. However, the concept of profit is incorrectly and loosely used as equivalent to net farm income in chapter 5 even though it was properly defined in chapter 4. Whole-farm budgeting is handled in a manner that some will consider a short-cut approach and utilizes the concept of gross margins obtained from enterprise budgets as the basic building block of the farm plan. No suggested planning formats are presented for estimating specific crop and livestock expense, seasonal labor balances, feed production-requirements balances, or machinery cost.

Part 3 addresses the control function of management and includes two financial-oriented chapters dealing with use of balance sheets and income statements and two chapters on farm business analysis and farm records.

Part 4 includes six chapters on the acquisition and management of resources. One chapter discusses the pros and cons of different forms of business organizations, a topic not usually included in farm management texts. The section also includes two financial chapters dealing with credit use and investment analysis. Separate chapters follow on land use, labor management, and machinery manage-

ment. Labor efficiency and farm work simplification are inadequately covered. The discussion of machinery management is well-organized and comprehensive.

Part 5 includes three chapters on miscellaneous topics—income tax management, risk and uncertainty, and professional farm management. The chapter on professional farm management will be useful to some but this space could have been better used to discuss more central issues.

A relatively short farm management text is bound to have some omissions. Little or no mention or discussion deals with farmstead planning, exit and entry processes, marketing alternatives and strategies, environmental concerns, and government programs that impact on farm planning and resource control decisions.

Despite the criticisms above, this is an excellent addition to the available farm management texts and is likely to be widely adopted. The examples, illustrations, and topics considered are not regionally specific. The level of sophistication with respect to basic economics and quantitative tools is modest. The book is unusually well written in a clear, systematic, and concise manner. The narrative proceeds in a logical fashion often following a numbered series of points or issues to be discussed. Each chapter opens with a numbered list of objectives to be pursued and ends with a summary and a set of questions for review and further thought. The reference list and data sets are current and appropriate. This proposed text could be used with a minimum of supplemental readings, a condition of considerable appeal to students. Parts 1 and 2 are essential building blocks for the text. Chapters in other units could easily be reordered or omitted with little or no loss of continuity or understanding.

Luther H. Keller
University of Tennessee

Lichfield, Nathaniel, and Haim Darin-Drabkin. *Land Policy in Planning*. Boston: George Allen & Unwin, 1980, viii + 321 pp., $39.95.

The main theme of this book is that plans are meant to be implemented and the concern of the authors is to see how the implementation process works and how it might be improved. For the purpose of the book, planning refers to local physical development planning; and it is the British experience that is under scrutiny. Britain is often looked to for its developed planning process, but the reason for its eminence in this area is largely historical accident. A further boost to the planning process in Britain was provided by the need to rebuild large areas of several cities following World War II bomb damage. In their search for better plan implementation, the authors turn for guidance not only to past British experience but to experience in other countries also. One chapter and a substantial appendix are devoted to the latter.

The book divides into three sections, the first of which is largely of an introductory nature and is, I feel, the most disappointing part of the book. In a book such as this, concerned as it is with policy implementation, much underlying theory must be taken as given, with references provided to specific texts. To attempt to deal with such general problems as the economics of market failure in an introductory section does not do the subject justice and, as here, often gives an air of superficiality. This is a pity because the rest of the book is indeed stimulating. The third section comprises just one chapter and presents the authors' ideas on how to reduce the plan-implementation gap and, thus, to improve the implementation process. Section two forms the core of the book.

At the end of the introductory section, the authors conclude that, "planning in a mixed economy has to aim at planned development, which recognises the role of the market but seeks to control it towards social ends" (p. 99). The second section is about how this planned development has been achieved in Britain. Running through the central part of the book is a secondary and fascinating theme concerning the question of equity, or distributional effects, of the various planning policies. Land policy planning has two distinct but not wholly separable components. It seeks to improve allocative efficiency in land use but must be seen to do so in an equitable manner. The inefficiency of unplanned piecemeal development and the effects on land values of various land use policies are served by well-developed theory and may thus be termed international in character. The treatment of the equity effects of what in Britain is termed betterment and in U.S. parlance as windfall and wipeout is, on the other hand, distinctly national and specific to given societies. It seems that such societal views may well be time-specific as well because, as this section of the book shows, British policy at different points in time has viewed these equity effects differently. On the allocative side, the main issues seem to be whether negative planning or planning control is sufficient to guarantee planned development or whether planning authorities need to become involved in a positive

haps the lesson from this section is that this is an area of economic policy where there can be no bipartisan concensus.

Overall, the book is marred by poor production—several quotations are unattributed, printing errors remain, and the footnotes to chapter five appear to be wrongly numbered. The book has a disappointing introductory section but a stimulating central argument, and it is hoped by this reviewer that the former will not detract from the latter the wide readership that it deserves.

Richard R. Barnett,
University of York, England.

Murdock, Steve H., and F. Larry Leistritz. *Energy Development in the Western United States.* New York: Praeger Publishers, 1979, xix + 363 pp., price unknown.

Rising real energy prices during the 1970s, in concert with federal policies to encourage energy independence, greatly accelerated fossil fuel exploration and development in the energy-rich western United States. Not surprisingly, the accompanying rapid infusion of population and development capital into primarily isolated agrarian communities placed severe strains on existing social, economic, and institutional structures. Concern over negative impacts on rural communities, as manifested in an abundance of impact study funds, spawned a great deal of impact assessment research. This book attempts to pull together in one volume some basic observations and generalizations from this growing body of literature. Specifically, the intent of the authors is "to provide an overview of the major dimensions of the social, economic and demographic impacts of energy development on rural areas in the western U.S."

The content and structure of the book, as well as the writing style, suggest a broad audience. The text is readable and should prove useful not only to economists but also to interested social scientists and policy makers. In terms of content, the early chapters of the text (1–3) provide the reader with an introduction to some of the unique physical, historical, and institutional aspects of the rural West which impinge upon community response to energy development. The central chapters (4–9) contain a more detailed discussion of specific effects associated with rapid development, such as demographic changes, alterations in the existing economic base due the imposition of development projects and increased demands on community services. The concluding chapters (10–12) attempt first to integrate the descriptive material from previous chapters into a research framework using examples from fairly comprehensive demographic-economic models and then lead the reader through the myriad of federal and state programs which may provide mitigative assistance to developing communities. A particularly useful feature of each chapter is a short terminal section which presents generalizations for the region drawn from the site-specific data bases and assessment efforts reported in each chapter.

A limitation of most impact assessment work is that the trade-off between meeting short-term informational needs and developing a more general body of knowledge appears to have been decided in favor of specific short-term needs. A strength of this text is that it deals with somewhat broader issues of community development rather than mere data collection and description. By dealing with assessment impacts in this broader context, the authors provide some conceptual rigor to assessment research as well as identification of serious data gaps and problems associated with extending localized study results to entire regions or states.

There are few shortcomings worth noting. The authors cite numerous *ex ante* assessment studies on specific communities to arrive at a range of plausible development effects; yet no *ex post* information (on actual effects) is provided to place the accuracy of these assessments in perspective. An evaluation of the relative predictive ability of some of these specific assessment efforts would allow the reader to judge the value of information provided to decision makers.

In discussing social impacts, the authors point out that such assessments by sociologists are often descriptive at best, with little attempt to impart any form of theoretical structure to the problem area. To a lesser extent, the same appears to be true about the assessment of the effects within the economist's purview. While the authors attempt to provide some suggestions as to an integrating mechanism, the impact assessment area still appears plagued by a lack of formal structure.

Finally, an unavoidable problem associated with any effort of this type is that development is continuing (at perhaps an accelerated pace), compared with the period over which the incorporated analyses were generated. Hence, events and literature that have evolved in the ensuing two years are not included. One would hope, however, that the validity of the generalizations remains intact.

Overall, this book proves to be a useful, descriptive synthesis of the types and magnitudes of community effects being experienced in many parts of the western United States. Indeed the major contribution of this book is to identify common themes from the rather diverse set of site-specific research and assessment studies and thus expand the general level of knowledge on this topic. While the authors readily admit that a complete presentation of impact issues and previous research is beyond the scope of one book, they have succeeded in gleaning a number of important generalizations from the literature which are suggestive of the range of effects as well as future directions for assessment research.

Richard M. Adams
University of Wyoming

Randall, Alan. ***Resource Economics: An Economic Approach to Natural Resource and Environmental Policy.*** **Columbus, Ohio: Grid Publishing Company, 1981, xiii + 415 pp., price unknown.**

Resource Economics: An Economic Approach to Natural Resource and Environmental Policy is intended as an undergraduate text. It includes much of intermediate microeconomics, welfare economics, exhaustible and renewable resource theory, water economics, and environmental economics. Other topics are covered as well—each of them briefly.

The author's Preface explains much of the way the book was written. "Such courses [in Natural Resource Economics] often attract a diverse group of students" (p. xii). The book is simultaneously pitched to the professional economists and the freshman environmental studies major. One group or the other usually loses out. The freshman will not find the discussion of option value or consumers' surplus helpful, while the senior economics major will find the discussion of the Faustman formula too simple. The discussion of Marshallian and Hicksian demand, I believe, pleases no one. But, there are the (many) parts that are just right for everyone. My favorite was the distinction between compensating and equivalent variation—a difficult concept concisely explained.

The book's philosophical orientation, "If there were no need for resource and environmental policy, there would be no need for applied resource economics" (p. xi), is carried through much of the book. The sections on environmental economics, and particularly the Tellico Dam case study, tie resource economics to environmental policy. The discussion of the Hotelling-Clawson-Knetsch transport cost procedure and the hedonic valuation of air pollution procedure were similarly infused with a (somewhat jaded) practitioner's viewpoint. Randall is clear on what these things can and cannot do.

Disappointing to me were the sections on renewable and exhaustible resources. A scant eighteen pages explain minerals, fish, and forests. All the interesting details—such as the capital theory-traditional fisheries debate, or the redundancy of salmon fishery gear—are lost. The book presents only the capital theory rule for exhaustible resources and does not really explain how such resources enter the analysis. Forestry is described only as an optimization problem; the institutions and their rules of thumb, which are policy, are neither described nor analyzed.

Where the author's contribution is uneven, the publisher's is not. The typeface and layout are so inferior that I would rather read the *Federal Register*.

In summary, *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy* is a long book of uneven quality written to many different audiences.

Peter Berck
University of California, Berkeley

Redman, Barbara J., and John C. Redman. ***Microeconomics: Resource Allocation and Price Theory.*** **Westport, Conn: AVI Publishing Co. 1981, ix + 289 pp. price unknown.**

The authors state in the preface they have "found that many beginning graduate students who either transferred from other fields of study, such as agriculture, mathematics, psychology, sociology, etc., or did not have the opportunity to pursue economics to the level usually expected of beginning graduate students need a beginning course on an intermediate level covering some of the basic principles of economics necessary to analyze problems which are economic in nature. For such courses, we hope that this volume will lessen the burden for both the instructor and the students." Unfortunately, the authors did not achieve their objective.

An intermediate microeconomics textbook should have two characteristics. First, it should cover the material relevant for an intermediate microeconomics course. Second, the discussion should be lucid and provide insights to enhance the readers' understanding of the material. This book receives a passing mark on content. However, it receives a failing mark on lucidity.

Apparently neither the authors nor the publisher took seriously their editing responsibilities. The sixty-six word sentence in the above quote is indicative of the authors' writing style.

Readability is to some extent judgmental. Therefore, the book's entire section on income elasticity is quoted so that prospective readers can make their own judgment about the book's potential as a textbook.

"The level of income has a substantial effect on the amount of a given commodity a person will purchase. The income elasticity (E_i) gives a numerical indication of the responsiveness of a consumer's purchases of a commodity to a change in income. It may be defined as

$$E_i = \frac{\text{relative change in quantity of commodity purchased}}{\text{relative change in income}}$$

or $E_i = dq/q \div dI/I$ which is equivalent to $(dq/dI)(I/q)$. This concept explains how the purchases by a consumer of a given commodity change as income changes with prices remaining constant. The income elasticity can have various positive or negative values. For example, if a 1% increase in income causes a 5% increase in the amount of commodity X purchased, the E_i for commodity X would be a 5; if a 1% increase in income causes a 0.2 or a 0.3% increase in quantity, as is apparently the case of food, the E_i would be 0.2 or 0.3 which means that commodity X is normal since E_i is positive. All income elasticities of normal goods are positive, and income elasticities of inferior goods are negative. A commodity with a negative income elasticity is one for which an increase in income

leads to a decrease in the amount purchased. Some food commodities such as potatoes have a negative income elasticity. If the E_i of demand for a commodity is greater than one, it indicates that an increasing proportion of the consumer's income is spent on the commodity as the income increases. Likewise, if the E_i is less than one, the proportion of income spent on the good falls as income increases. It has been suggested that unitary income elasticity can be considered roughly as the dividing line which separates luxury commodities from those in the necessity category. Under this suggestion, those commodities with income elasticities greater than one would be luxuries and those with income elasticities less than one would be necessities.

"In cases where exactly all of the increase in income is spent on the commodity, the income elasticity is equal to the reciprocal of the proportion of the consumer's income spent on the commodity. Thus,

$$E_i = \frac{1}{kX}$$

where kX refers to the proportion of the income spent on X. This means that if a person is spending 5% (1/20) of his or her income on X and if the person has a 1% increase in income and spends it all on X, he or she will increase the expenditure on X by 20%, thus giving an E_i of 20 for commodity X. If less than all of the increase in income is spent on X, then the $E_i < \frac{1}{kX}$ and vice versa" (p 141).

The final chapter discusses general equilibrium. The reader is more likely to be confused than enlightened by this chapter. In fact, the final paragraph of the book indicates that the authors may have confused themselves on this topic.

"It is beyond the scope of this book on (static) resource allocation and price theory to debate the relative merits of allocative vs. dynamic efficiency if these must be incompatible, especially in the absence of much hard evidence and the abundance of value judgments required concerning the priority of present vs. future generations' consumption, but the importance of dynamic efficiency to static resource allocation cannot be denied" (p. 289).

The book contains the standard microeconomic topics. However, it does have more of an agricultural orientation than most microeconomic textbooks. Unfortunately, this orientation does not overcome the other shortcomings of the book.

J. Bruce Bullock
Oklahoma State University

Thomas-Lycklama à Nijeholt, Geertje. *On the Road for Work: Migratory Workers on the East Coast of the United States,* Series on the Development of Societies, vol. 7. Boston: Martinus Nijhoff Publishing , 1980, xii + 211 pp., $16.00.

The primary objective of the book as stated by the author is to combine "statistical data analysis with descriptive reports on the workers' lives and work" (p. x). The first two chapters and part of the fourth are devoted largely to descriptive reports while the fifth and sixth chapters are the statistical data anlysis. The third chapter describes the political and legislative climate, yet no mention is made anywhere of the extensive CETA 303 programs. The book ends with a conclusions and policy implications chapter. The author closes by noting two conditions which must be met to improve migratory farm workers' future: (*a*) "effective government measures must be implemented to halt the entry of new, economically weak workers into the migratory farm labor stream" (p. 181), and (*b*) strong unions must be created to increase the bargaining power of workers relative to employers (p. 192). The book offers a particular perspective on farm labor, but its lack of balance and sound analysis preclude its usefulness for policy making. Most important, no consideration is given to evaluating trade-offs between various groups affected by policy changes.

The first part of the book dealing with descriptive reports of farm workers freely mixes quotations from published works with the author's own observations on farm workers. Particularly disturbing is the intermingling of reports from the 1930s through the 1970s without discerning changes which have taken place over time. For example, the Department of Labor's Annual Worker Plan is given a great deal of credit for coordinating employment between states, as supported in 1955 and 1959 publications. It is, however, not recognized by the author that during the 1970s, employment arrangements have been coordinated largely outside the formal system with the Annual Worker Plan falling into virtual disuse (Kirschner).

The second section of the book presenting statistical data analysis is seriously lacking in depth. The data utilized in this section were collected in fourteen states under regional project NE-58; greater reliance on original sources would have eliminated unnecessary redundance.[1] In presenting descriptive material, the author chooses to present the raw sample data. A discussion of the more appropriate estimated population characteristics, recognizing the stratified random sampling procedure can be found in many of the original NE-58 publications.

Migratory workers are compared with nonmigratory workers on the basis of estimated earnings relationships for each set. The estimated relations, however, are at best only a description of the two portions of the sample rather than a representation of the respective structures. First, the author examines relationships linear in earnings when it is well documented that the log of earnings is the appropriate specification (Mincer). Also ignored is the extent to which migratory workers have chosen to migrate because their earnings are greater than if they do not migrate, and vice versa, i.e., selectivity bias. Both sexes are included in the same earnings

[1] The author was not associated with that group.

relationships with only a dummy intercept shifter when the common practice is to estimate separate male and female earnings relationships. Finally, no attempt was made to carry out a simple F test for significant differences between the migratory and nonmigratory relations.

The author claims to have found evidence of discrimination. The support is based on the coefficients of the ethnic group dummy variables in the earnings regressions. While it may be true that there is discrimination, the analysis in support of the argument needs a great deal more structure. Not only are the earnings relations not well specified, but no effort was made to draw upon the economic discrimination literature and examine, for example, market discrimination coefficients (Becker).

The final exercise in examining the fourteen-state data was to present no fewer than nineteen two- and three-way classification tables to distinguish migratory from nonmigratory workers. The conclusion is drawn that ethnicity is the determinant factor in migration (p. 157). Rarely are we able to draw such sharp conclusions; one can only wonder why the relatively limited tabular analysis was done rather than a more appropriate multivariate analysis.

If one is looking for an economic analysis of farm workers, it will not be found here. In this reviewer's opinion, the book falls far short of meeting the original objective of combining descriptive reports with statistical data analysis. To truly combine the two approaches would require drawing inferences and observations from the same samples. Not only are these different samples, but the time frame differs considerably in many cases. Moreover, the author's own interspersed observations often deviate considerably from the current farm labor market and conditions.

Robert D. Emerson
University of Florida

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Mincer, Jacob. *Schooling, Experience, and Earnings.* New York: National Bureau of Economic Research, 1974.

Necrology

Ira W. Arthur, professor of economics at Iowa State University, died in June 1981. He was 88.

Murray Reed Benedict, retired professor of agricultural economics, University of California, Berkeley, died in September 1980. He was 88.

James Bowring, retired resource economics professor, University of New Hampshire, died in November 1980 at 69 years of age.

Emer E. Broadbent, professor emeritus of livestock marketing, University of Illinois, died at age 65 in October 1980.

Siegfried V. Ciriacy-Wantrup, professor emeritus of agricultural economics, University of California, Berkeley, died in October 1980. He was 74.

Arthur G. Conover, retired economist with USDA, died at age 68 in November 1980.

Noah S. Hadley, professor emeritus of agricultural economics, Purdue University, died at age 75.

Howard Laird Hall, international economist with USDA, died in October 1980. He was 65.

William F. Henry, professor of resource economics, University of New Hampshire, died in July 1981. He was 66 years old.

Elton B. Hill, emeritus professor of agricultural economics, Michigan State University, died in December 1980.

William Frank Hughes, retired USDA resource economist, died in July 1980 at age 70.

Sidney Ishee, professor of agricultural and resource economics, University of Maryland, died at age 55 in October 1980.

Oscar B. Jesness, professor emeritus of agricultural economics, University of Minnesota, died in November 1980. He was 91.

M. Slade Kendrick, retired professor of economics and agricultural economics at Cornell University, died in June 1980 at 85 years of age.

E. Fred Koller, professor emeritus of agricultural and applied economics, University of Minnesota, died in September 1980.

Adrian H. Lindsey died at age 84 in May 1981. He was professor emeritus at the University of Massachusetts.

Daniel Upton Livermore, professor emeritus of agricultural economics, Virginia Polytechnic Institute, died in October 1980.

James C. McCall, extension director in St. Lucie County, Florida, died at age 59 in July 1980.

Gene McMurtry, associate director of extension, University of Massachusetts, died in January 1981 at age 55.

Dharm Narain, director of the Production Program at IFPRI, died at age 55 in October 1980.

Edmond A. Perregaux, emeritus professor of agricultural economics, University of Connecticut, died in April 1981, at 86 years of age.

Robert Cooke Ross, retired professor of farm management at the University of Illinois, died in September 1979 at age 88.

Snider William Skinner, retired international economist with USDA, died in October 1980.

Arlyn R. Staroba died in January 1981 in an automobile accident. He was extension associate at North Dakota State University.

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Mail subscriptions	(*a*) 5,885	(*b*) 5,945
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Total distribution	(*a*) 5,888	(*b*) 5,948
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All manuscripts and editorial correspondence, except as noted below, should be addressed to the editor, James P. Houck, Department of Agricultural and Applied Economics, 332 Classroom Office Bldg., University of Minnesota, St. Paul, MN 55108

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Volume 63 Number 5

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General Sessions

Specific Sessions

Deregulation and Its Consequences for Agriculture

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John W. Mellor

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Ben C. French
Philip M. Raup
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James D. Shaffer

Ben C. French

1981 Fellow

Professor, Department of Agricultural Economics, University of California, Davis, 1959 to date; Michigan State University, 1953–58; Vice-chairman/Chairman, 1960–66 and 1976–present.
Vice-president, American Farm Economic Association, 1965–66.
President, Western Agricultural Economics Association, 1970–71.
Editorial Council, *Journal of Farm Economics*, 1962–65.
Research awards: Outstanding Ph.D. thesis, AFEA, 1954; Outstanding Research, AFEA, WFEA, 1957; WAEA, 1957 and 1980.
Consultant: USAID, USDA, Congress of the United States, various agricultural firms.

Ben C. French has made distinguished contributions to the profession in research, teaching, and administration. His standards of excellence are recognized by his students, readers of his research reports, and by the faculty and administrators of his institution.

French was born in California in 1923. His academic work was at Berkeley, where he completed his B.S., M.S., and Ph.D. degrees. He joined the faculty at Michigan State University in 1953, and, in 1959, returned to the University of California-Davis.

His research is noted for its depth and innovativeness. The landmark *Hilgardia* monograph on economic efficiency in plant operations, coauthored with Sammet and Bressler, was developed from his award-winning thesis. The influence of this research on the profession is documented in his excellent review article in *Survey of Agricultural Economics Literature*, volume 1. His research papers reflect a continued interest in efficiency in agricultural marketing in areas such as assembly cost functions (article republished in *Readings in the Economics of Agriculture*), subsector model analysis, and pricing efficiency with long-term contracts. Another focus of research is on applied econometric studies, where his supply response specification for perennial crops has been recognized as particularly innovative. In spite of teaching and administrative duties, his research contributions continue to explore new paths, such as the quantitative analysis of marketing control programs.

Ben French is a dedicated teacher at both the undergraduate and graduate levels. One has but to borrow his lecture notes to see the thoughtful and rigorous development of the subject matter. He has developed new courses and opened areas for research using a systems approach. Ph.D. thesis students, with Ben on the committee, have learned to expect no-holds-barred review comments, good-natured encouragement, and firm guidance. Many of his former students now hold prominent positions in universities, businesses, and government.

Of his twenty-two years at Davis, eleven years have been as chairman or vice-chairman. During these two decades, strong programs have developed at both the graduate and undergraduate levels, due in no small measure to Ben's contributions. His contributions in research, teaching, and service to his university and the profession continue to be substantial.

Philip M. Raup

1981 Fellow

Professor, Department of Agricultural and Applied Economics, University of Minnesota, 1953 to date. Professor, Department of Agricultural Economics, University of Wisconsin, 1949–53.

Member, Editorial Board, *Land Economics,* 1949 to date.

Member, Social Science Research Council Committee on Agricultural Economics, 1961–65; Executive Committee, Agricultural History Society, 1962–63; Committee on Long-Range Land-Use Planning, National Planning Association, 1979 to date.

Member, Board of Directors, American Agricultural Economics Association, 1975–78.

Philip M. Raup has been an effective classroom teacher, an insightful researcher, a student of world agriculture, and a provocative public speaker. He has traveled and lectured widely, served in an advisory role in local, state, and federal governments, contributed broadly to his profession, and collaborated with international agencies.

Phil Raup was born in Kansas in 1914. His education included an A.B. in economics at the University of Kansas, and an M.S. and Ph.D. at the University of Wisconsin. After a year as a research fellow at the Brookings Institution, he entered military service, eventually serving four years in the Office of Military Government for Germany in Berlin. He joined the faculty of the University of Wisconsin in 1949, leaving in 1953 for the University of Minnesota.

Raup has taught courses in land economics, land tenure, and world agricultural development. He has sensitized students to the importance of institutional arrangements, while fascinating them with his broad knowledge of people and facts. He has influenced generations of students, both domestic and foreign, and has taken a keen interest in their later careers.

Professor Raup's catholic interests, broad reading, and sharp intellect make him widely respected in the University community. He often serves on graduate committees in numerous other academic departments. His ability to challenge audiences to think differently,

and thereby to reason, has made him much in demand as a public speaker in the United States as well as other countries. Even when people disagree with him, they still respect the mental refurbishing he caused them to do.

Raup's research over the years has been far-reaching. His quest for facts and flair for detail make him a veritable walking encyclopedia of knowledge on world agriculture. His research has been consistently relevant to contemporary policy issues, and he has a unique talent for searching out data to illuminate a relationship or challenge a widely held belief.

Raup is one of this nation's few scholars of the agriculture in Eastern Europe and the Soviet Union. As a member of a multidisciplinary team, he has visited the same locations in the Soviet Union on a regular basis over a twenty-year period. Among other publications these visits led to, a book, *The Changing Structure of Europe: Economic, Social, and Political Trends,* he coauthored with four of his University of Minnesota colleagues.

For many years Raup had an important influence on land economics work in the United States, particularly the North Central region, where he was an active member of the North Central Land Tenure Research Committee (NCR-6). He also has participated actively with city and state government, the USDA, FAO, the European Commission on Agriculture, and the World Bank.

Raup has had a long and productive career. He has been a prolific writer and public speaker, has demonstrated excellence in many fields of agricultural economics and to world agriculture. He has added to our knowledge in significant ways.

James D. Shaffer

1981 Fellow

Professor, Department of Agricultural Economics, Michigan State University, 1953 to present.
AAEA Award in 1980 for distinguished policy contributions through NC-117, "Organization and Control of the U.S. Food Production and Distribution System."
Consultant to U.S. Department of Agriculture/Economics, Statistics, and Cooperatives Service, 1967–68 and 1980.
Director, Center for Rural Manpower and Public Affairs, Michigan State University, 1974–79.
Chairman of the Michigan Agricultural Marketing and Bargaining Board, 1973 to present.

James D. Shaffer is an intellectual leader and a truly innovative scholar in the agricultural economics profession. Not content with conventional economic theory and its application to contemporary economic problems, he constantly seeks new approaches to the solution of difficult social problems. He has been unusually creative in drawing upon ideas and concepts being developed in several social sciences. Through his extensive writing, teaching, and interaction with other professionals he has stimulated and influenced policies and programs in food system organization and public policy.

Shaffer was raised in Michigan. He received his Ph.D. at Michigan State University and has been a faculty member there since 1949. Shaffer's career has reflected a strong commitment to the missions of the USDA/land grant university system. Early in his career, Shaffer attracted attention for his pioneering work on consumer behavior and demand for food. He worked closely with Dr. Gerald Quackenbush in the development and operation of the MSU Consumer Panel which served as a basis for many publications on food purchasing patterns and the socioeconomic factors underlying the demand for food.

In the 1960s, his research interests shifted toward policy questions in the organization and performance of the U.S. food system. He has become a national leader in developing new approaches to marketing research. His 1968 working paper concerning publicly sup-

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G. Edward Schuh

G. Edward Schuh

1981–82 President

Professor and Head, Department of Agricultural and Applied Economics, University of Minnesota, 1979 to date.
Professor, Department of Agricultural Economics, Purdue University, 1959–79; and program advisor, Ford Foundation-Brazil, 1966–72.
Director, Center for Public Policy and Public Administration, Purdue University, 1977–78.
Senior Staff Economist, President's Council of Economic Advisors, 1974–75; Deputy Undersecretary for International Affairs and Commodity Programs, USDA, 1978–79.
Award for outstanding Ph.D. thesis, AAEA, 1961; Professor *Honoris Causis,* Federal University of Vicosa, Brazil, 1965; award for outstanding published research, AAEA, 1971; special *Homenagen,* Brazilian Society of Agricultural Economics, 1973; award for best article published in *American Journal of Agricultural Economics,* 1974; award for distinguished contribution to policy, AAEA, 1979.
Director, American Agricultural Economics Association, 1977–80; chairman, Awards Committee for Published Research, 1969–70.
Elected a Fellow, American Academy of Arts and Sciences, 1977.

G. Edward Schuh has been professor and head, Department of Agricultural and Applied Economics, University of Minnesota, since 1979. Previously, he was professor of agricultural economics at Purdue University from 1959–79.

Schuh was born on a vegetable farm outside of Indianapolis, Indiana. He received a B.S. from Purdue University in 1952 and an M.S. in agricultural economics from Michigan State University in 1954. After two years of military service he entered the University of Chicago, receiving an M.A. in economics in 1958 and a Ph.D. in 1961.

Schuh joined the agricultural economics faculty at Purdue University in September 1959. While on the Purdue faculty, he served as visiting professor at the Federal University of Vicosa in Brazil, 1963–65, as program advisor to the Ford Foundation in Brazil, 1966–72, and as first director of the Center for Public Policy and Public Administration, 1977–78. At Purdue he taught graduate level courses in advanced production economics, agricultural policy, applied econometrics, research methodology, welfare economics, and economic development. His research concentrated on supply response, agricultural factor markets, agricultural and trade policy, agricultural development, and rural poverty.

Schuh spent a 1968–69 sabbatical as research fellow at the Development Advisory Service, Harvard University. He was a senior staff economist with the President's Council of Economic Advisors, 1974–75, and Deputy Undersecretary for International Affairs and Commodity Programs, USDA, 1977–78. He has been a consultant to the USDA, to the Ford Foundation in India and Brazil, to the International Agricultural Research Centers, to the Consultative Group for International Agricultural Research, and to other universities and international organizations.

Schuh received the Association's award for Outstanding Doctoral Dissertation in 1961, for Outstanding Published Research in 1971, for Best Journal Article in 1974, and Distinguished Policy Contributions in 1979. He was named Professor *Honoris Causis* at the Federal University of Vicosa in Brazil in 1965 and received a special *Homenagen* from the Brazilian Society for Agricultural Economics in 1973. In 1977, he was elected a Fellow of the American Academy of Arts and Sciences.

General Sessions

Economics and International Relations: A Conceptual Framework

G. Edward Schuh

The world which is rising into existence is still half encumbered by the remains of the world which is waning into decay; and amidst the vast perplexity of human affairs, none can say how much of ancient institutions and former manners will remain, or how much will completely disappear.

Alexis de Tocqueville

Economics has experienced a number of mini-revolutions in the post-World War II period. We have absorbed the revolution of mathematics and quantitative techniques. Capital theory has been transformed as we broadened it to include human capital, with all the new insights this more inclusive concept has provided to the theory of income distribution, trade theory, and the theory of economic development (Schultz 1964, Becker). We have revitalized our insights into the family and the household with the new household economics, rooted in the insights of Becker and Lancaster but going back at least to Margaret Reid. We are constructing a microeconomic base for our macroeconomic theory. We have reincorporated the "political" into political economy. And we finally are beginning to recognize that if economic entities are really as rational as we assume, they create serious problems for policy makers—an idea pointedly brought to our attention by the rational expectations school (Lucas and Sargent).

An important challenge still before us, however, is to understand the emerging world economic system and to devise the institutions that can make it more orderly. The theme of this paper is that within the corpus of economics, we have the conceptual and quantitative tools to understand this complex new world and to design a more orderly, efficient, and equitable international economic system. Moreover given the importance of agriculture in the world economy, it is likely that food and agricultural issues will dominate the international dialogue in the decades ahead. Because of our own proclivity to address applied problems, agricultural economists have important contributions to make in expanding that stock of knowledge.

U.S. foreign policy has been in disarray for at least a decade. Part of this disarray is because our relative political and economic power has clearly declined. At home our domestic institutions either were not designed for today's world, or they are evolving in directions that make it difficult (if not impossible) for us to deal with the world that is emerging. Perhaps uniquely among the democratic countries of the world, our president does not speak for a political party capable of being rallied to provide legislative support for his foreign policy—a phenomenon which baffles other countries. Within the federal bureaucracy there is a proliferation of agencies which play a role in foreign affairs. Moreover, the executive branch no longer makes foreign policy. It is made increasingly by a Congress that may be in opposition to the president, by the public through television and the newspapers, and even by the judiciary, as illustrated by the court challenge to our realignment of policy vis-à-vis mainland China and Taiwan.

There are two maintained hypotheses in this paper. The first is that—contrary to popular belief—the world is not really changing in ways that are beyond our capacity to manage or control. The world only appears to be out of control because we have not generated the knowledge that enables us to understand it and to manage it with wisdom rather than brute

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Presidential address.

G. Edward Schuh is Head, Department of Agricultural and Applied Economics, University of Minnesota.

Grateful acknowledgement is made for helpful comments on an earlier version of this paper.

political and economic power. The second maintained hypothesis is that many of the problems of international relations are fundamentally problems of economic structure and economic relations. Therefore, the contribution of economists is to assist policy makers in taking a strategic view of the world. However, economists to date have hardly addressed such questions. Equally as important, the issues before us go beyond trade and trade policy—important as those issues may be in their own right.

I will attempt to sketch the elements of a conceptual framework that can serve as a guide in understanding the economic dimension of our international relations and that can serve as a basis for structuring a more rational international economic policy. The intellectual foundation for a strategic conception of the world economy has at least four pillars: (*a*) development theory, especially that variant rooted in the theory of human capital and the new household economics; (*b*) the new institutional economics; (*c*) neoclassical trade theory; and (*d*) the theory of endogenous governmental behavior.

At least two of these provide us with a secular perspective on the evolution of particular economies, their institutions, and the institutions which link them together. The third provides a framework for understanding how an economy such as the United States relates to other national and supranational economies through trade and the international capital markets. The fourth provides a basis for understanding the behavior of governments.

It is worth emphasizing here how little attention economists trained in the neoclassical tradition give to the issues of longer-term growth and intercountry relationships. However, economists and other social scientists from different traditions have long given attention to them. The theory of imperialism rooted in the work of Schumpeter and Baran and Sweezy is an important example, as is the dependency theory of Frank and Cockroft, Frank, and Johnson. Dependency theory has fallen into disrepute as growth rates in many countries of the "Periphery" have outpaced those in the "Center."

Development Theory

The contribution of development theory is the insights it offers to the changes that can be expected in individual economies as they undergo economic development. These insights have to do with changes in the sectoral composition of output of individual countries and, in turn, with the international division of labor. They also have to do with the international distribution of income and patterns of trade likely to emerge.

Economists long have had notions of how the sectoral composition of output for an individual economy should evolve as it develops. List noted that as per capita incomes rise, labor would be transferred from the agricultural to the industrial sector. This tendency is one of the few universal constants one can identify as one looks across the range of countries in the world (Johnston). This simple notion also can be inverted and used as a limited theory of development, with the obvious policy prescription that labor should be removed from the low productivity agricultural sector and transferred to the high productivity industrial sector to obtain eocnomic growth.

Baumol extended this idea to a classic model of stagnation by noting that as development proceeds beyond the industrial state, more and more resources are transferred into the service sector. Since he postulates that productivity growth in the service sector is limited, changes in the sectoral composition of output as growth proceeds lead to stagnation. The critical element in this theory is that labor is both the means and end of production. Examples include the shift of labor from the assembly line to such activities as the performing arts, teaching, and other service activities. All of these typically expand as a country develops. If the demand for such activities should be relatively price inelastic and they should have a positive income elasticity of demand, the composition of the economy will shift toward them as the economy expands, and productivity along with per capita incomes will grow more slowly and ultimately stagnate.

The Baumol perspective is clearly in the tradition of early English economists. It is not pessimistic, however, since equilibrium comes at high per capita income levels. The more recent studies using macrosystem models (Forrester and Meadows et al.) are more directly in the early classical tradition. They point to an equilibrium dependent on increases in the service price of natural resources relative to capital and labor.

Schultz (1974b) suggested a somewhat different theory of equilibrium for the developing

economy that is still consistent with the Baumol perspective. Basing his ideas on Becker's time allocation model and the new household economics, Schultz argues that the ultimate constraint to development is the limit that a twenty-four-hour day puts on the development process. Contrary to Baumol, however, Schultz stands the classical world on its head. The ultimate constraint to development comes from limitations on time for the consumption of household-produced goods and services. This is a constraint within the household not arising from limits on resources or rising costs in production. However, the Schultz equilibrium is also at a high income level. Moreover, this theory is richer since, by including children as consumption goods, it includes a population as well as an income equilibrium.

Nerlove, although obviously in the Schultz tradition, provides a somewhat different perspective. He argues that productivity in the household, where both production and consumption take place, can be raised on a continual basis. Because human capital is one of the main outputs of the household, further investments in human capital actually increase the efficiency with which it can be produced. Hence, there is no reason for an equilibrium level of per capita incomes or population to exist.[1]

The insight that comes from the developmental perspective is that the sectoral composition of output changes as development proceeds. Moreover, the changes occur in response to the rising value of human time, which affects not only the structure of demand but the economic activities that are viable as an economy develops. Increases in per capita income are the essence of economic growth and development. But increases in per capita incomes lead to increases in the wage rate. The latter is significant for production both within the household and in the market place.

With capital accumulation, the industrial sector of an economy can expand relatively easily so long as labor can be released from the agricultural sector at approximately a constant supply price. As this process continues, the wage rate will rise and the country will lose its comparative advantage in labor-intensive manufactured products. The industrial sector will then decline, and the service and high technology sector will expand. Hence, industrialization is not the last stage of economic development; it is only a transition to a high-technology economy.

Of course, the increases in per capita income shift the structure of demand from agricultural output to industrial output to the demand for services and technology-intensive consumption goods. The road for the economy is not completely predictable, however, and one cannot be certain about how the sectoral composition of output will change or what the trade implications will be. U.S. agriculture, for example, has become a high technology industry and an important export sector for the United States.[2] Moreover, if capital can be substituted for labor, industrial activities may remain important as the wage rate rises, as the Japanese have demonstrated with their automobile industry.

These caveats aside, economic development exerts a powerful influence on the sectoral composition of output and on the structure of demand. This has important trade implications and, in turn, important implications for international economic relationships. The structure of demand for raw materials will change as development proceeds, as will the structural composition of aggregate demand.

At present, we find ourselves looking backward and wanting to reindustrialize America. Even granted that there are strategic implications involved, it surely is not in our best interest to turn back to a sectoral output composition that was appropriate for the past. We would be better advised to identify and promote those activities in which we have a comparative advantage. At this juncture, they are high-technology, human capital-intensive industries.

The important point in this context is that the force of economic development, with its associated rising value of human time, drives the economy to a human capital-intensive configuration (Schultz 1974b). Not to capitalize on that configuration is to fail to capture one's comparative advantage.

Another insight from development theory and the theory of human capital deals with

[1] Nerlove's model does predict declining rates of population growth and declining rates of infant mortality, the main features of the demographic transition.

[2] This result is counter to the *dependistas* who argued that the LDCs would be exploited by the advanced countries by virtue of their having to export agricultural products and other raw materials, for which they believed the terms of trade were declining, and importing manufactured products, whose terms of trade they believed were rising. See Prebisch and Singer.

population growth and its quality, both of which are important in a strategic sense. The theory argues that children, especially high-quality children, are time-intensive goods to produce. As per capita incomes rise, there is a strong quality component to the demand for children. This means that quality of children is substituted for quantity as development proceeds. The rising price of time associated with development exerts strong downward pressures on fertility rates. Whether this eventually leads to a population equilibrium or merely a decline in the population growth rate is still an open, and probably empirical, question.

The dynamics of population growth have several other dimensions which the United States will be facing in the next couple of decades. In our case, for example, we can not only expect a low population growth rate, but an aging of the population as well. We may well see a time when a predominant share of our population is elderly. This has important implications for the extent to which we want to depend on a labor-intensive industrial sector or import such goods. It also has important implications for our immigration policy. If we really do need to maintain some labor-intensive sectors for national security reasons, we may be much more willing to accept foreign immigrants in the future.

Finally, the human capital perspective changes the view we take about size of population. Historically, size of population has been an important dimension to the political and economic power countries enjoy on the international scene. But the human capital perspective enjoins us to view labor in both qualitative and quantitative dimensions. Hence, numbers are only part of the story, and probably not the most important. Knowledge and the quality of the labor force become critical. They should receive attention as we assess the strength and power of other countries as well as our own.

The New Institutional Economics

A body of literature has now developed from somewhat diverse sources which attempts to integrate the perspectives offered by the traditional institutional economics and modern neoclassical economics (Hayami and Ruttan, North and Davis, North and Thomas, Schultz 1968). This new perspective is described as the new institutional economics. Contrary to neoclassical economics, disequilbrium is an important characteristic. It argues that institutions and institutional change can be explained by past and present economic forces. This obviously has great import for understanding the development of particular economies and for understanding how individual countries relate to each other.

The institutional economics of John R. Commons was used to explain the evolution of economics and to analyze the effects of institutions on resource allocation and the distribution of income. The evolution of institutions themselves was explained in historical terms, with little room given to economic forces. Much of modern neoclassical economics, on the other hand, pretends that institutions do not exist.

An institution in the present context is a behavioral rule. Our interest, of course, is in those institutions that perform economic functions. These include institutions which govern control over resources and assets (such as private property rights), those that establish the framework for the production and distribution of public goods or services (educational institutions, research organizations, judicial arrangements), and those which prescribe how countries relate to each other economically (trade agreements, for example).

The contribution of the new institutional economics is to help us understand how institutions influence the growth path of individual countries, and how the pace and character of development, in turn, influence those institutions. It provides insights into how international institutions might evolve over time, while showing how those institutions might be better designed. It provides some basis for resolving the North-South debate which currently disturbs relations between the United States and the less developed countries.

One of the primary concerns of this paradigm is to explain nonmarket resource allocation, an important issue. The richness of the new perspective can be seen by the range of problems to which it has provided important insights. For example, Cheung, following Coase, argued that under competitive conditions private contracting between landowner and tenant would lead to the same resource allocation as if there had been competitive factor markets for labor and/or land. This leads to a completely different approach to land tenure arrangements and to property rights in general.

Hayami and Ruttan's work on induced

technical change pointed out how economic forces caused institutional change which then guides technological change onto an efficient growth path. The important insights from this research have generated additional work on efficient institutions and institutional change. (See Binswanger et al., and Ruttan, forthcoming.) Ruttan makes the important point that social scientists should produce institutional innovations in the same way that biological and physical scientists produce technological innovations. Their contribution to expanded income streams for society might be just as great in this role as is the contribution of the biological and physical scientist.

North and Davis, and North and Thomas provide new historical interpretations of the development of the U.S. economy and of the western world as a whole. Institutions and induced institutional change play important roles in these new interpretations. Roumasset specifies an efficiency framework to explain patterns in institutional arrangements found in agricultural production.

The new institutional economics has a number of implications for a strategic conception of the world economy. In the first place, it should make us more sensitive to differences in institutional arrangements among countries, while providing more insight into the rationale for the differences that exist.

Second, understanding the interactions between economic forces and institutions can provide important insights into the particular development trajectory that countries might take. For example, institutional arrangements will determine what share of investment resources are channeled to the formation of human capital and what particular form that human capital will take. Important implications for immigration and trade policy logically follow. Institutional arrangements also determine how externalities (positive or negative) are internalized, with obvious implications for the sectoral composition of output and the proportions in which resources are used. Institutional arrangements will also determine whether the development process is focused onto an efficient or an inefficient growth path.

An especially important class of related problems has to do with the future evolution of the centrally planned economies. Marxian thought may be inverted: centrally planned economics may have the seeds of their own destruction built into the system. The internal contradiction of the centrally planned economies may be rooted in the imperative to invest in human capital as a means to keep up with the more decentralized, industrial countries of the West. Such investments may lead the population of these economies to develop new perspectives on their own institutions. Alternatively, the failure to permit the appropriate institutional changes to take place may condemn the centrally planned economies to a slow-growth trajectory.

The new institutional economics also offers insights into the shape that economic and political unions might take. Economic unions typically occur when gains from trade can be internalized within a partial or complete political unification. Recognition of this explains why economic and political union often goes only so far and then stops.

A superficial look at the Mexican and U.S. economies suggests that there is sufficient resource complementarity to make a case for economic union. Mexico has an abundance of oil and a rapidly growing, young, and unskilled labor force. The United States is short on oil and has a human capital-abundant, aging, and slow-growing population. The disparities in economic and political power make union difficult, however. Insights from the new institutional economics should provide important guidelines as to how to design the institutions that will make economic and political union possible—with enormous strategic implications to the whole world.

A proposition from trade theory offers another example of the potential role of the new institutional economics. The theory of optimal currency areas provides an explanation for why important regions of individual countries have chronically lagged behind other regions. Leff has argued that had northeast Brazil been a separate country with a separate currency, it might well not have lagged behind the rest of Brazil. The same probably applies to the U.S. South and to the south of Italy.

Political pressures can build up in particular regions causing them to break away from the central government. More generally, cases where such exchange rate disparities are likely to arise will be poor candidates for economic and political union. But, armed with the insights of both the theory of optimal currency areas and the new institutional economics, one might be able to design institutional arrangements such as multiple exchange rates that would lead to stable economic and political units.

Other institutional design questions are apparent. In the tradition of Ruttan and the induced innovation hypothesis, what institutions are needed and what support can be found for them to do the research and perform the educational missions pertinent to the international socioeconomic-political system? National intelligence agencies should be doing some of the research on these issues. But to leave such research to the intelligence agencies will be inadequate. Multiple research and education institutions are needed. Moreover, the issues are of national and international interest, not just state or local interest.

A second set of institutional design questions has to do with international economic institutions. The world has become increasingly interdependent. The exchange rate regime has changed, an effective international capital market has emerged, and trade patterns are changing dramatically. All of this is taking place with ever-widening differences in per capita income. Comparative advantage is also shifting rapidly among countries. Such rapid shifts make adjustment more difficult and create political problems.

The end of World War II saw a burst of creativity in new international institutions such as the GATT and the Bretton-Woods conventions. Unfortunately, most were designed by the advanced industrial countries for their own benefit. Moreover, they were predicated, for the most part, on a fixed exchange rate regime.

Today, international political and economic power has changed significantly. The international capital market has grown, while the relative importance of concessional foreign aid and the international migration of labor has declined. The social, economic, and political world is just very different than it was several decades ago.

The southern participants of the North-South debate have been the loudest and most articulate proponents of institutional change in the international community. Yet even in the United States and other industrialized countries there is general dissatisfaction with arrangements for international economic and political intercourse.

The questions here are legion. What institutions are needed to manage the international monetary system? Of what value is GATT when most of the less developed countries (LDCs) are not members despite their growing importance in international trade? How can these other countries be brought in? What institutions can be developed to facilitate trade adjustment and more rapid trade liberalization?

Neoclassical Trade Theory

The neoclassical theory of international trade is not a particularly powerful predictor of trade flows in the complex world of today. However, recent extensions of the theory and growing empirical research enable us to understand trade patterns with greater assurance than even a decade ago.

Despite recent contributions, trade theory is still usually cast in a comparative cost framework. Perhaps the most widely used version is the factor proportions explanation of trade developed by Heckscher, Ohlin, and Samuelson. The standard version of this theory is expressed as a $2\times2\times2$ general equilibrium model. It assumes that production functions are identical across countries and first-order homogenous and that all factors of production can be translated into efficiency units of capital and labor. It assumes that capital is not mobile internationally. It also assumes there are no factor-intensity reversals, and it ignores goods and factor-market distortions. Finally, it is a static theory, and usually assumes "similar" preference structures across countries.

Empirical evidence and common observation question most of these assumptions. In the first place, it has long been recognized that developing countries have large agricultural sectors and trade in primary commodities cannot be explained by endowments of labor and capital alone. Agricultural production requires the services of land in addition to labor and capital. This means that the $2\times2\times2$ model is not very helpful in explaining patterns of agricultural trade. Second, production technology is generally not perfectly mobile across national boundaries, especially in agriculture where technology tends to be location specific. This challenges the common production function assumption.

Third, a rather large and efficient international market for capital has evolved, represented in part by the transnational firms which create so much controversy. Fourth, factor-intensity reversals are fairly common, especially in agriculture (Naya). At low wage-rental ratios agriculture tends to be labor-intensive relative to industry. At high wage-rental ratios, agriculture is capital-inten-

sive relative to industry. For example, agricultural production in the United States tends to be more capital intensive than industrial production, but in Southeast Asia it is more labor-intensive. The existence of different elasticities of substitution in the two sectors is sufficient to ensure that a factor-intensity reversal will occur.

Fifth, goods and factor-market distortions are legion in most countries. Governments intervene in the economy in various ways, often with the specific objective of changing the free play of market forces. Sixth, the extensive risk and uncertainty associated with trade cannot be handled with static models. And finally, Valavanis-Vail demonstrated long ago that demand can reverse a country's trade flows from that predicted by a production-based theory of comparative advantage.

Despite these serious limitations to the standard theory, considerable progress has been made in recent years to extend this framework to provide more realistic and useful models. Considerations of demand and product differentiation have been given increased attention in recent studies (Pagoulatos and Sorenson). The issue of imperfect product markets has been addressed and attempts made to understand trade flows in this broader context (Caves, McCalla, Schmitz and McCalla). Helpman and Razin and Jabara and Thompson have demonstrated that if policy makers are risk-averse, the expected-utility maximizing output bundle is not that produced under free trade, even after correcting for domestic distortions. Instead, expected utility is maximized when domestic prices are distorted away from the international terms of trade by the subjective cost associated with international price uncertainty.

Schmitz and others have extended the simple trade model to account for trade in intermediate goods (Bieri and Schmitz). Jones (1967) has incorporated international capital movements into the theory of tariffs and trade. The literature on the transnational corporation is burgeoning.

Krueger (1977) has examined the possible impact of goods and factor-market distortions on trade patterns. To do this, she found that a meaningful interpretation of the Heckscher-Ohlin-Samuelson model must lie within the manufacturing sector in a world of many commodities and many countries. With this broader perspective, she found that the predictions of the theory were more likely borne out in patterns of specialization within manufacturing than in comparisons of factor proportions in exporting and import-competing industries. Moreover, she found that the relevant endowments were those within manufacturing and not of the entire country.

From our perspective, perhaps the most significant extensions of the theory have been to take account of differences in human capital variables across countries. Kenen's contributions (1965, 1968, 1970) have been especially important in this context, but the work of Keesing (1965, 1966, 1968a, 1968b, 1974) Baldwin, Bharadwaj and Bhagwati, and Stern and Maskus is also important. All show an important role for human capital in explaining trade patterns.

Valentini and Schuh argued that the identical technology assumption of the Heckscher-Ohlin-Samuelson trade model can be salvaged in agriculture with the meta-production function of Hayami and Ruttan in place of the conventional production function. The Hayami-Ruttan framework also provides an explanation for the scarce-factor-saving bias observed in agricultural technology across countries. The Valentini-Schuh model specifies a separable production function as a way of taking account of factor biases in the technology. This is more realistic than Jones' three-factor model, which assumes that each sector uses only two inputs, despite the presence of three inputs in the model. Our statistical tests show that the Hayami-Ruttan human capital variables have a strong influence on trade patterns.

A final dimension to the relationships that trade theory can illuminate is the issue of who gains from trade and what are the sizes of these gains. Considerable controversy still rages over this issue. Neoclassical economists implicitly assume them to be large. Opponents of neoclassical economics and of free trade policy either appeal to dependency theory or unequal exchange (Arghiri). Both imply that one trading partner gains at the expense of another. Proponents of the latter view argue that shifts in the terms of trade show who benefits and who loses from trade. Proponents of the neoclassical view argue that shifts in the terms of trade reflect changes in technology and quality of products. They argue that changes in the terms of trade are generally of less significance than proponents of the opposing view think.

Neither side in this debate has given sufficient attention to the fact that the gains and losses are determined by developments on

both the trade and capital accounts. Brandao has taken a fairly simple trade model and derived the welfare function for an individual country. He finds that whether a country gains or loses from trade is determined not only by the terms on which exports and imports are exchanged, but also by the terms on which capital is exchanged.

The new perspective emerging from modern trade theory can serve as a basis for determining foreign policy and as an important field of economic research. First, our international relations ought to be strongly influenced by the directions of trade and investment flows. Surprisingly, little attention has been given by economists to identifying the locus of comparative advantage and how it might be shifting. U.S. agricultural trade, for example, has shifted strongly toward the centrally planned and LDCs. Yet our international posture hardly reflects this shift, nor does the state of our knowledge about the countries involved.[3]

Within the LDCs, our exports are growing most rapidly to the middle-income countries with rapid growth in per capita incomes. This illustrates the importance of economic development as the source of expanding markets for our exports and emphasizes the important link between economic development and trade.

Similarly, we have done little to evaluate where the marginal productivity of capital might be highest for international investment. Naively, Congress mandated some years ago that our concessional assistance had to be channeled to the poorest of the poor.[4] We abandoned the middle-income countries, many of which were making remarkable progress on the road to economic development. How much economic growth was sacrificed as a consequence of this misguided policy is not known.

The emerging patterns of trade and investment should be a key ingredient in shaping our foreign policy. The key to making such projections is to understand the changing patterns of comparative advantage. The emerging human capital perspective provides a framework for making more realistic projections. It also provides a useful framework for shaping our foreign assistance policy, but except for H. G. Johnson and Schultz, economists have hardly scratched the surface on the economics of foreign aid.

The Theory of Endogenous Governmental Behavior

Most neoclassical economics takes government as a given, treats it as exogenous to the private sector, ignores it, or assumes that it is irrational. Such treatment is a paradox, for the participation of government is pervasive in most economies. The tendency has been for this role to increase over time. Moreover, there is no obvious reason why we should expect governments to be either irrational or unresponsive to economic forces.

Trying to understand the behavior of government is important for three reasons. First, the sheer size of government as a component of economic activities is large in many countries. Second, government is the primary means by which income and wealth are redistributed. The distribution of income and wealth is important to understanding the economics of individual countries.

Finally, government economic policy tends to be pervasive in the economy. A distortion in a relative price will tend to affect all consumers and all producers of the product. Moreover, these effects will spill over from product markets to factor markets, and vice versa. Hence, to ignore government behavior is to leave unexplained a great deal that is important.

Fortunately, a theory or theories of government behavior is (are) emerging that offers considerable promise. Rausser, Lichtenberg, and Lattimore have recently reviewed and synthesized literature which relates to democratic societies. They find that a number of conceptual formulations have been advanced to describe endogenous government behavior. They classify these formulations into four paradigms: (*a*) the liberal-pluralist framework, (*b*) the theory-of-state framework, (*c*) the theory of economic regulation framework, and (*d*) the rent-seeking interest group and conflict resolution framework.

The liberal-pluralist framework is found largely in the public finance literature. There is a large number of variants of this paradigm, but the names of Downs, and Buchanan and Tullock stand out. In general, these models

[3] For a penetrating study of the food and agriculture sectors of the centrally planned economies, see D. Gale Johnson.

[4] In 1975 Congress established "new directions" for U.S. foreign assistance by requiring that the foreign aid agencies give special attention to agricultural productivity, population growth, infant mortality, unemployment, and income distribution. This legislation was well-intentioned. However, it was poorly conceived in concept. For a critique of the agricultural mandate, see Schuh and Thompson.

focus primarily on the policy-setting process and on the relationship between policy makers and voters in particular. Policy relates to societal income distribution. Income alone is considered the indicator of well-being, regardless of source. The effects of voters' interests are described in terms of the distribution of income.

The "theory of the state" paradigm emanates from radical economics (Jessop, O'Connor, and Roemer). Contrary to the liberal-pluralist paradigm, which is based upon a "state" which emerges from an atomistic exchange economy, this paradigm presumes that government institutions emerge from one dominant interest group with significant monopoly power. Moreoever, this formulation focuses upon groups of agents called "classes" rather than individuals. It concentrates on election and legislative choice as well as bureaucratic processes.

The theory of economic regulation owes its origins to Stigler, Posner, and Peltzman. This framework treats government intervention and regulations as normal economic goods subject to the standard economic calculus. Consumers and producers are viewed as demanding government interventions of various kinds, most of which can be interpreted as taxes. The regulators must then seek to balance the marginal political return from an income transfer with the marginal political cost of the associated tax. This paradigm focuses on the election process.

The rent-seeking interest groups and conflict resolution paradigm was partially characterized by Krueger. Zusman and Brock and Magee also have made important contributions. This framework admits both economic and political markets and a process for resolving conflicting goals. Contrary to the economic regulation paradigm, power is not swept under the rug. Instead its formation and effectiveness assume a central role. Moreover, rents are presumed to exist in both economic and political markets. The value of this framework is in the understanding of election and bureaucratic choice processes.

Another important body of literature on government behavior deals with the centrally planned economies, and in particular with the policy cycles that emerge in those countries. It turns out that stagnating growth, which results from increasingly severe distortions, leads to liberalization of policy and faster growth, only to be followed again by growing distortions, stagnating growth, and a repetition of the cycle. (For an example, see Brainard.)

An important contribution of the emerging theory of endogenous government regulation is that it provides insights into how income and wealth are redistributed. Income and wealth are redistributed largely through government intervention. By understanding government behavior we are able to understand some of the forces affecting changes in the distribution of income. This makes for a more complete explanation of the economy.

This research also leads to the concept of efficient distribution.[5] This framework is useful for testing hypotheses about whether government intervention is redistributing income and wealth in an efficient manner. The ability to do this is of obvious importance in understanding whether an economy is on an efficient growth path.

Castle notes the universal nature of the self-interest hypothesis and argues that it applies to the private and public sector alike. He provides possible explanations for why much government behavior appears to be perverse to the skeptical eye of the economist, particularly when such behavior leads to policies which grossly distort efficiency prices in the guise of redistributing income.

Another example of the importance and potential of this perspective can be seen from D. Gale Johnson's study of the centrally planned economies. He finds that the introduction of substantial food price subsidies is an important reason for the rapid growth of agricultural imports by those countries. Understanding these policies is the key to understanding the role these economies will play in international commodity markets in the years ahead. Moreover, it will be the key to knowing the posture the United States should take vis-à-vis food security.

Similarly, the kind and degree of government intervention is important in determining the particular growth path an economy will be on and the rate at which it will grow. This theory provides the means of understanding these issues. This in turn provides a basis for policy vis-à-vis that economy. Ultimately, the theory of government behavior provides the link between politics and economics and

[5] Becker (1980) has provided an important step in providing a formal specification of a model from which tests of hypotheses can be made about the efficiency of income redistributions. For an application of such tests in the context of agricultural commodity markets, see Gardner.

among the three previous pillars of this conceptual framework.

Finally, the theory of endogenous governmental behavior provides a means to understand the planning processes which are important in many countries. Here the questions are legion. One would like to know whether the revealed preferences of public agencies are consistent with the policy objectives stipulated by legislative mandates. Similarly, one would like to know the nature and directions of causation between government structure, behavior, and the how, what, and when of the production of public goods and services.

Key Research Areas

The conceptual framework sketched out above is rudimentary and incomplete. The brief surveys of literature are also incomplete. The four elements of the broader framework are not yet well integrated. However, even in this sketchy outline there are important guidelines for future work which will provide a more adequate analytical framework for understanding the economic dimensions of international relations.

To conclude, it would seem useful to enumerate some of the key research issues which need attention. Among these are the following:

(*a*) The impact of economic growth on the sectoral composition of output.

(*b*) The extent to which knowledge can substitute for natural resource constraints in the process of growth.

(*c*) The impact of investments in human capital on comparative advantage.

(*d*) The relationship between investments in human capital and the optimal level of population.

(*e*) The interactions among economic growth, institutions, and investments in capital of all forms.

(*f*) Institutional designs to facilitate economic intercourse among nation states and to help resolve environmental problems.

(*g*) Identification and measurement of the gains and losses from trade, with separate treatment of commodity markets, capital markets, and services.

(*h*) The behavior of governmental units at all levels, ranging from state trading agencies, through national governments to international agencies.

(*i*) The efficiency of income redistribution policies, at both the national and international levels.

(*j*) The linkages among resource endowments, government policies, institutional change, and the growth path of economies.

The above problems are tractable with our present analytical and quantitative tools. These problems are important to agriculture in particular and to the development of a saner, more productive, and more equitable world economy. Agricultural economists in particular have the tools and instincts for dealing with problems such as these. It is in our grasp to help make this a better world for our compatriots and for humanity as a whole.

> ". . . creative economic theory is a mushroom that lives on the wood of experience. . . ."
>
> Samuelson

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Government and Agriculture Revisited: A Review of Two Decades of Change

Dale E. Hathaway

It has now been exactly two decades since I last attempted a comprehensive overview of U.S. food and fiber policy; that review was published as *Government and Agriculture, Economic Policy in a Democratic Society.* Thus, it seems appropriate, as one whose professional life has been spent studying and participating in the policy process, to use this opportunity to examine what has happened in the past two decades and look at where we are headed.

I will focus my review on price and income policy, which I believe is more correctly called commodity policy. I will ignore such important areas as resources use, environment, and rural development for two reasons. One is the obvious lack of space. The other is simply that commodity policy has been and continues to be the core of farm politics, despite the attempts of several secretaries of agriculture to make it otherwise. It is still the basis of the U.S. Department of Agriculture's relationships with the agricultural and agribusiness community.

I will limit my comments to three related issues that have brought great changes to commodity policy; they are (*a*) the restructuring of American agriculture, (*b*) the move to international markets, and (*c*) the changing politics and players in commodity programs.

The period 1961–81 has been one of the most tumultuous in U.S. peacetime history. It opened with the inauguration of the nation's youngest president, who promised to lead the nation toward new frontiers; it closed with the inauguration of the nation's oldest president, who has vowed to return the nation to values and glories of a previous, less complex period. In the area of economic policy, the past two decades saw many of the economic institutions developed in the thirties and forties become inadequate to deal with the tasks for which they were designed, as did many of the economic theories and the policies associated with them. As a result, the nation experienced postwar highs in unemployment and inflation, sometimes simultaneously. The dominance of U.S. economic and political power around the world receded as the "miracles" of growth in Western Europe, Japan, and numerous developing countries occurred throughout the 1960s and 1970s. Although it was not immediately obvious at the time, many of these changes were to have a profound effect on the U.S. food and fiber economy and the related policies that influence it.

Closing the Economic Gap in Agriculture

One of the most important changes to occur in the past two decades has been the economic changes which restructured U.S. agricultural production. Two decades ago substantially more resources were committed to producing food and fiber in the United States than could be justified by the return on investment. On the average the return on these resources in farming was lower than a return to a similar resource investment would have been off the farm; by 1980 this was no longer true. Throughout the 1950s and 1960s per capita income of the farm population ranged from half to two-thirds that of nonfarmers. In 1971 the per capita disposable income of the farm population exceeded 75% of the disposable income of the nonfarm population for the first time in modern history. It has been more than 84% of the nonfarm average in every year except one since 1972, and over 100% in several years. However rough these figures, there can be little doubt that, on the average, the resources producing farm products in the United States have been earning returns comparable to those in nonfarm activities in most years of the last decade. Moreover, if one

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Fellow's Address.

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takes the inflation-induced capital gains into account, the farm production sector may have enjoyed the largest net gain in real wealth of any major sector in the economy over the past decade.

This is not to suggest that this was true for every producer or for most producers every year. Indeed, quite the contrary was true. Periodically during the 1970s and even now, many producers of some commodities found that they were "trapped" in a position where their cash expenses exceeded their cash incomes, and they were forced to resort to living on inflation-created capital gains or to liquidate their farm businesses. This sense of being economically "trapped" led to large and violent farmer protests in Washington in 1978 and 1979 and the formation of a new agricultural organization, the American Agricultural Movement.

In the 1960s there was widespread belief that the return to resource investment and farm incomes would be intolerably low in the absence of government programs like acreage allotments, marketing quotas, and land retirement programs. The 1970s convinced most producers that these programs could be dismantled and that market forces would produce adequate returns to resources in agriculture for most producers in most years. Thus, the 1970s saw the final dismantling of the network of ineffective production control programs that had been the hallmark of our basic commodity programs since the 1930s. Equally if not more important was a change in perception about government accumulation of commodity stocks. During the 1960s government stockpiling was expected to increase farm income; by the 1970s the farm community was convinced that government stocks depressed prices and income. This change in perception was to alter the policies of government intervention in agricultural commodity markets in a major and probably permanent fashion.

Some observers have suggested that the commodity policies of the 1970s were a continuation of a long trend toward supporting prices at world market levels. I believe that the evolution of policy can be read differently.

Restructuring American Agriculture

In my view, commodity price policy follows rather than leads events in our governmental system. Thus, the changes in policy that have occurred over the past two decades come as a result of changing conditions and not vice versa.

Part of the changes that were to lead to new policies were major changes in the agricultural producing sector. As a result of low returns in agriculture, new entrants in commercial agriculture declined. A decade of sustained growth in nonfarm jobs in the 1960s provided economic opportunities for those who might otherwise have become farmers. The number of workers, both family and hired, employed in agriculture continued to decline during the 1960s at about the same rate as it had in the 1950s.

Over time this process which involved off-farm migration, retirement, off-farm work for some family members, and consolidation and enlargement of farm operations via sales, rental, and new capital infusion produced a commercial agriculture which was far different than existed in 1960. Economies of scale were achieved or exceeded in almost every type of farm in the United States.

The extent of this restructuring is so major that it nearly defies comprehension. In 1960 there were just under 4.0 million farms, with an average net farm income of $2,806. In 1979 there were 2.3 million farms with an average net farm income of $11,526. In 1960, however, farms with an annual sales income of $20,000 provided 48% of all farm products. In 1979 those with sales over $40,000 (a rough adjustment for inflation) provided 82% of all products. In 1960 there was a marked decline in family income from all sources as the volume of farm sales declined. In 1979 the family income is almost flat at $20,000 regardless of sales volume of the farm until the volume of sales is over $40,000 when more resources produce higher average incomes as volume rises.

The massive restructuring of commercial agriculture meant the agricultural labor market was fully integrated with the nonfarm labor market, perhaps for the first time. Simultaneously, an integration of the capital and credit markets also occurred as the modern commercial farms came to depend more and more on outside capital and credit to finance farm enlargement, machinery purchases, and large cash expenditures for annual operation. By the late 1970s the net income from farming had declined to a fifth or less of gross, while in the 1950s it had constituted a third of gross

income. At the same time, commercial farms became extremely sensitive to nonfarm input cost and interest rates.

These changes in the allocation of resources and in the economic situation in commercial agriculture were two significant changes that heralded a shift in the basic U.S. commodity policy. These basic changes in the agricultural economy led to a move away from price supports above market clearing levels and production controls. In the Agricultural Act of 1973 the Republicans finally achieved the market-oriented policies they had sought unsuccessfully throughout the 1950s. They prevailed, however, not because virtue finally triumphed, but because it finally became obvious to most of the farm commodity groups that the old programs had little relevance to their economic well-being.

The Evolution from National to International Markets

The market for farm products two decades ago was relatively slow-growing and stable. In the 1950s the major market for U.S. farm output was at home. By 1960 much of the instability of domestic demand had been removed from the market by income transfer programs that stabilized the demand for food regardless of the business cycle. The foreign markets for U.S. farm products were modest, and mostly the result of U.S. government programs—PL 480, export subsidies, and export credits. Year-to-year changes in export demand brought changes in government stocks, not in domestic farm prices and incomes.

However, during the last two decades the most significant change in demand has come from abroad. In 1960 U.S. agricultural exports totaled only $4.8 billion with a $1 billion surplus in the U.S. agricultural balance of payments, the first such surplus in decades, apart from wartime. By 1980 the level of agricultural exports was over $40 billion with a $20 billion surplus in balance of payments.

The Growth of International Markets

Looking back, it is possible to see that the turning point in the U.S. agricultural export market occurred about two decades ago. It was not until 1957 that the constant dollar value of farm exports exceeded the 1929 level. Therefore, in 1960 there was no strong evidence to suggest that foreign markets would become an increasing factor in the demand for U.S. farm products. In 1950, farm exports produced 9% of cash marketing receipts, in 1970 only 14%, and by 1980 they constituted almost one-third.

The rising export demand that was to change U.S. commodity policy was primarily a result of three factors, although it was influenced by several others. The first was the major growth in world economy outside the United States, led by growth of the Japanese and European economies during the 1960s and early 1970s, followed by some of the high-growth developing countries such as Korea, Brazil, and Taiwan. A second was the population boom in the developing world as medical science lowered death rates more rapidly than birth rates. Concurrently, most developing countries followed policies that failed to invest adequately in agriculture or encourage the adoption of new agricultural technology. Thus, as a group, developing countries shifted from self-sufficiency in food grains to huge net importers of grain in the 1970s. The third factor was the failure of Communist centrally planned agriculture to produce enough food to meet the rising demand for food, especially meats, in their own countries. One by one, the centrally planned economies entered world markets, starting in the mid-1960s and increasing throughout the 1970s. By 1980, these countries together were importing 80 million tons of grains and oilseeds annually, whereas ten years earlier they were not significant importers as a group.

In 1960 world wheat and coarse grain trade totaled 66 million metric tons and the U.S. provided 44%, or 29 million tons. By 1970, world trade in those commodities was 101 million tons, with the U.S. share at 39%. The Russian grain sale of 1972–73 jumped world trade volume in wheat and coarse grains to about 130 million tons, putting the U.S. share at 55%. By 1980, however, the world trade was approaching 200 million tons and the U.S. share was up to 58%.

There also were several ancillary factors which contributed to our rapid export expansion. One was the maintenance of U.S. price supports for grains, oilseeds, and cotton at or below world market levels, a move that began in the mid-1960s and has continued regardless of the political party in power. A second was the devaluation of the dollar and the termina-

tion of the fixed exchange rates which had overvalued the dollar and overpriced our agricultural exports. A third was detente and the ensuing expansion of our trade relations with the Soviet Union and the East Bloc; and finally, the normalization of our diplomatic relations with China.

The confluence of two events, the restructuring of U.S. agriculture and the boom in export markets, was not the result of well-calculated policy, nor was it foreseen by most observers. As a result, the commodity policies of the past decade have been mostly ad hoc attempts to adjust to new economic realities. We are, at the beginning of the 1980s, a long way from achieving a policy which is consistent with the economic and political realities of the world in which we live.

Who Makes Policy: The Congress

While most people recognize that a major change has taken place in the structure of U.S. agriculture and its markets, there is less understanding of the changes this has brought to the politics of agriculture and how the changing face of U.S. politics has in turn related to the substantially different agricultural sector of the 1970s. Indeed, the nonfarm press often implies that little has changed from the days of the old farm bloc.

Washington policy makers in their annual appearance before the venerable Jamie Whitten, chairman of the House Subcommittee on Agricultural Appropriations, tend to think "the more things change, the more they remain the same" as they listen to the chairman tell them how he instructed Secretary Benson to sell farm products abroad at world prices in 1954. But, in reality, there have been profound changes in Congress and the changes have affected the style and substance of farm policy.

First, the average tenure of members of both Houses has declined markedly since 1960. Less than one-third of the forty-seven members of the House Agricultural Committee that wrote the 1977 Farm Bill had ever written such a bill before, and the 1981 bill will be addressed by an equally new group. Part of the congressional turnover is caused by the coattails of the lopsided presidential victories of 1964, 1972, and 1980. Part also is due to the rise of the two-party system in the South, the area that had traditionally dominated the congressional agricultural committees.

Second, committee discipline has disappeared and, despite the current Republican steamroller, there has been no real party discipline in the Congress for a long time on commodity issues. Open government has led to open markup of legislation in committee and in conference, providing the single-issue lobbyist with a field day. The congressional committee process, insofar as the substantive committees on agriculture are concerned, has been dominated by a collection of commodity group representatives primarily concerned with the single or few commodities predominant in their district. One feature that has changed little is the individual commodity focus of the agricultural committees. Observers used to decry the excessive influence of certain commodities in the old farm bloc, but now the focus is more than ever on single commodities. Most thoughtful members are conscious of the trend and privately lament it, but in their public action they have little alternative but to follow the most exorbitant demands of their constituent group.

This could, and sometimes does, lead to blatant excesses and bad policy, dairy and peanut programs being a case in point. The more generous treatment of rice and wheat programs also results from this system.

But, there are two major controls which tend to offset the actions of the agricultural committees and further muddy the policy process. One is the necessity for floor action by the entire chamber. Gone is the day when a committee bill reported by a senior agricultural chairman of the House or Senate was immune from amendment on the floor. Sugar legislation pushed by the sugar and sweetener-producing lobbies met its demise on the House floor in 1974 and again in 1979, and it was the threat of a similar fate that caused the dairy lobby to compromise in 1981.

A second and more powerful check on the substantive committees are the budget committees which were created in the 1970s. These committees have immense power to limit funds that will be required to implement policy. It is in the budget committees that commodity program expenditures must be balanced against social programs, defense, and other national needs. More than any other influence, the congressional budget committees shape national policy, overshadowing both the appropriations committees (which can allocate funds within a sector) and the substantive committees.

Another marked change in the past two decades concerns congressional staff. The congressional Budget Committee has a large professional staff; moreover, each of the substantive committees have sizeable professional staffs. In addition, many individual members now have highly trained professionals on their personal staffs. This explosion of professional congressional staff is a mixed blessing. On one hand, it may reduce the dependence of an individual member on a lobbyist or on the executive branch for information and analysis. On the other hand, it is clear that the congressional staff has all the elements of a bureaucracy including arrogance, lack of responsiveness, and in many cases, a tendency to act as if they were the individual who was elected to make the nation's laws.

However much one may have disliked the old congressional seniority system that existed two decades ago, it is difficult to argue that the present open system which has evolved under the guise of democracy is an improvement. In fact, the new system is a hunting ground for well-financed single-interest groups in all areas, commodity programs, gun control, or social programs, and probably results in less thoughtful and less responsible legislation than that produced by the closed seniority system.

The Executive Branch

Changes in U.S. agricultural markets, the U.S. economy, and the nature of commodity policy have slowly and steadily shifted the decision-making power concerning agriculture within the executive branch. Part of the power shift has occurred within the Department of Agriculture and part between the USDA and other agencies in the executive.

From the 1930s through the 1960s the political power base of the USDA was anchored in the network of state and county committees created under the Agricultural Adjustment Act of 1933 to administer the price support, production adjustment, and agricultural conservation payment (ACP) programs. This organization, first called the Agricultural Adjustment Administration (AAA), then Production and Marketing Administration (PMA), and now Agricultural Stabilization and Conservation Service (ASCS), had its own ties to the commodity groups whose programs it administered and to the congressional farm bloc. Much has been written about its power, its feuds with the farm organizations, and various attempts to bring it under policy control. Traditionally, its administrator answered directly to the secretary of agriculture and to the president.

As its domestic price support and control programs became less significant, the ASCS role in policy began to diminish. In 1969, the Republicans put ASCS under an assistant secretary for international affairs and commodity programs. This effectively moved the policy coordination between domestic and international commodity programs one step away from the Secretary.

More importantly, as international markets for U.S. commercial agriculture became more significant, a major new set of actors outside the USDA entered the agricultural policy process. In the 1950s and 1960s, the USDA had to share policy decisions with the Council of Economic Advisors (CEA) and the Bureau of the Budget because of White House concerns with consumer prices and budget costs.

The expansion in world food trade which surged in the 1970s enlarged the policy-making circle. It rapidly grew to include the State Department, Treasury, the U.S. Trade Representative, and the National Security Council, in addition to the CEA and Office of Management and Budget (OMB). As more agencies, and indeed, cabinet officers became involved in commodity policy decisions, the more these decisions were shifted from the secretary of agriculture to the White House. As some people so unkindly put it, "agricultural policy has become too important to be left to the secretary of agriculture."

This widened participation and shift in the decision-making process created several problems and frustrations that are still unsolved. One is the belief increasingly held by farmers that crucial farm policy decisions are out of the hands of USDA and being made by persons who are unfamiliar with their problems and concerns. In many respects they are correct. Most of the knowledge and analytical capability of the U.S. government regarding world food and agriculture still is in the USDA, and the others involved in commodity policy are either dependent upon USDA analysis or sometimes have little basis for judgment.

It is a curious and somewhat unsettling fact that none of the past four presidents, including the incumbent, have been able to evolve a stable and satisfactory policy process within the executive branch to deal with agricultural

commodity policy. Open warfare between the secretary of agriculture and the secretary of state seems to be a hallmark of Republican administrations. It was no secret that the Democrats had similar, if not as vocally explicit, problems under President Carter. Over the past decades there have been councils, committees, special assistants and other White House attempts to coordinate agricultural commodity policy and make it more rational. None have worked and none probably will.

The inherent reason for the problem is that there is no other department with a major domestic constituency and domestic programs that is also deeply involved in international trade and international affairs. No other sector of the U.S. economy has the economic and political ties to a single department as farmers do to the USDA. No other sector simultaneously sees other departments with quite different interests and constituencies constantly and repeatedly intervening in matters they view as important to their economic well-being.

During the 1950s and 1960s, agricultural policy was made by a tightly knit group that evolved from within USDA. It agreed with, and was highly susceptible to, domestic commodity groups and like-minded congressional committees. Now the participants in agricultural policy decisions appear to come from a sprawling, ill-defined group that seems to be beyond the access of farmers and domestic commodity groups. Increasingly, the secretary of agriculture and his senior policy officials involved in commodity policy have become negotiators and intermediaries between the traditional political forces and the new policy participants. As is the case in all such situations, none of the parties completely trust the intermediaries and all parties blame them for whatever they do not like.

The Agricultural Groups

Two decades ago it was possible to sense that the changes in U.S. agriculture were creating great difficulties for the general farm organizations. As the family farm evolved into more specialized production units, the general farm organizations were not able to bridge the gaps between the specialized economic interests of these production units and provide comprehensive political and economic commodity policies. Nor were they able to offer the intensified, special attention and representation these specialized producers seemed to demand.

As a result, highly specialized groups of producer representatives which represent specific commodity producers (wheat, corn, soybeans, cotton, dairy) have developed. These organizations, which nearly parallel the commodity blocs in Congress, have well-paid Washington representatives who generally are more influential in their specific commodity areas than the general farm organizations are.

In addition to the overall farm organizations and the individual commodity organizations, there are two new groups that have increased in importance and influence on agricultural commodity policy. One is the agricultural cooperators group which was organized as the private sector representatives in the foreign market development activities of the USDA. These cooperator groups, operating with combined producers and USDA funds, have become a major force in international commodity policy on such diverse issues as trade and grain negotiations and export credit. In many ways they have developed the same interlocking political interests with the Foreign Agriculture Service (FAS) that the old commodity groups had with ASCS and its predecessors. And, not surprisingly, controlling FAS has become a problem for the secretary of agriculture, just as controlling the independent policy of ASCS was once a problem.

A second powerful force that has arisen during the past two decades is based in the agribusiness-exporter community. This group represents the interest of private firms and cooperatives whose economic well-being depends upon the rapidly growing agricultural export business. While the most publicity has been given the larger grain exporters, those familiar with the Washington scene know that the specialty-crop cooperatives, cotton exporters, and a handful of rice exporters have exercised immense power on issues of critical importance to their export business. Of course, since ample supplies and moderate prices are good for the export business, these agribusiness groups have added their considerable support, in a quiet way, to policies that maintain moderate price supports, full production, and high export levels.

The rise of the single-interest commodity groups increases the historic problem of achieving coherent, consistent domestic and international commodity policies. Given the

narrow focus of the single-issue commodity groups, there are only two participants in the decision-making process that work toward a balanced commodity policy. They are the general farm organizations and the executive branch of government. Thus, in the 1970s the two traditional antagonists, regardless of administration, the secretary of agriculture and the American Farm Bureau Federation, were more in agreement than in conflict—a marked departure from the general hostility and sometimes open warfare that marked much of the period from the 1930s through the 1960s.

Thus, in the 1970s, on policy matters involving general farm legislation, trade negotiations, and other international agricultural issues the old-line farm organizations acted as an important moderating and countervailing force to the individual commodity groups and narrower economic interests they represent.

Oddly enough, what once was a weakness of the general farm organizations may become their strength in the new policy arena. Many have commented in the past that the general farm organizations' tendency to take positions on broad national and international economic policy issues diluted their effectiveness on commodity policy. But now inflation rates, interest rates, and general trade policy are the base upon which commodity policy rests. Thus, the ability to understand and take positions on all these issues is giving these general organizations a greater influence in commodity policy.

Where We Are Now

Despite some political-philosophical claims to the contrary, the evolution to an international market policy has not been without pain for many agricultural producers and associated industries. This pain has been reflected in their political reaction, and I predict that neither the economic problems nor the political reactions in the agricultural sector have run their course.

Until the 1970s, U.S. agricultural producers had relative price stability for both agricultural inputs and outputs, while demand for U.S. agricultural commodities steadily rose. Now, and over a relatively brief time, all of these stable elements have become uncertain in an agricultural economy highly vulnerable to instability. As we face the decade of the eighties, this instability in demand and price for agricultural inputs as well as commodity prices would appear to be one of the policy issues that must be addressed.

It is useful to remember the sources of that increased instability. Export demand for U.S. commodities is in part a function of world weather, especially in the USSR and a few other major importing countries, as well as in other major exporting countries such as Argentina, Australia, and Canada. Thus, in addition to the instability generated by weather in the United States, the instability of weather and crop yields around the world is also reflected in the demand for U.S. agricultural exports.

Second, the nature of the economies that are increasingly dominating world trade in grains, oilseeds, and cotton also adds to demand instability. The LDCs and the centrally planned economies have accounted for most of the growth in U.S. agricultural exports. Most centrally planned and LDC economies have state-controlled central buying units. In a traditional sense, our growing export markets are not markets at all. Lower or higher commodity prices are not translated into changes in consumer prices, within those importing countries. The decision to import and how much to import is based more on internal political circumstances than on economic market mechanisms. All of these factors add to the instability in the export market.

Finally, in that portion of the world where market mechanisms actually operate, we find tariffs and variable levies applied to agricultural commodity imports to prevent world market prices from affecting internal markets. In the few really open markets that do operate, flexible exchange rates can and do affect import demand in ways and degrees that were not anticipated.

Demand instability is, of course, reflected in unstable commodity prices. Some idea of the impact of this instability can be seen by comparing the year-to-year variations in farm prices and incomes in different periods. The variation in crop prices from 1972–78 was six times that of 1955–63, and four and one-half times that of 1964–71. For farm income, the variation in the 1972–78 period was two and one-half times that in 1955–63, and one and one-half times that of 1964–71. The most stable element in the system has now become nonfarm income of farm people, hardly a consolation to full-time commercial farmers. For

crop producers, the use of target prices has been the first line of defense and protection against the instability of demand. This concept, adopted from a 1930s income payment program, offers some protection against low prices but is both expensive and highly asymmetrical in terms of economic costs and benefits.

Target prices for wheat and feed grains offer no protection to dairy, meat, or poultry producers, or ultimately, to consumers who are subject to sharp export-induced price increases. In order to deal better with the inherent instability facing U.S. agriculture in a world market, the administration implemented and the Congress approved in 1977 a farmer-owned reserve program for wheat and feed grains. Not surprisingly, the individual commodity groups have tried to use the reserve as a price support program rather than a supply-price stabilization program.

For forty years, the U.S. government tried and learned, more or less, how to maintain the price of farm commodities during periods of excess capacity and surpluses. We have had little experience and have not learned how to maintain reasonable price stability that is required both by farm producers and consumers at home and abroad, even though efforts have been made.

When I was a graduate student, *Agriculture in an Unstable Economy* (Schultz) was an important work for both its theory and its policy applications. But for a long period, mostly because of federal commodity programs, instability was a relatively insignificant issue in farm policy.

Now once again instability will be a policy issue in the next decade. On the cost side, commercial agriculture finds itself at the mercy of OPEC, U.S. and world monetary policy, and worldwide industrial price policy for inputs such as steel, fertilizers, and chemicals. On the market side, there is unstable demand, unstable exchange rates, unpredictable U.S. government trade policies and unpredictable foreign government policies regarding imports. In my view, the U.S. agricultural producers are only beginning to understand the nature and extent of this instability and the adverse consequences it can have upon their economic well-being.

Not surprisingly, the debate will focus on the proper role of the federal government in stabilizing commodity prices in the new economic context. But, the debate and policy actions will bring conflicts that are new to commodity policy.

On one hand, the commodity producers who are now feeling the full brunt of the new instability will push for policies that expand demand and maintain high, stable, commodity prices. On the other side will be the broad array of consumer and domestic users whose economic interests are best served by controlling price increases. We have already seen three short-supply embargoes in the past few years; and, for a variety of reasons, they have been the most disruptive policy actions taken by the federal government since the inauguration of commodity policies in the 1930s.

One tends to forget that the old domestic commodity programs evolved into a system whereby nobody was surprised—not farmers, marketers, speculators, or consumers. Moreover, most were involved in the development of the policies. But the new government interventions have surprised everyone, pleased few, and enraged the commodity producers more than any single issue in decades.

A related but somewhat different issue will revolve around the proper role of government in international commodity affairs. In a world where international commodity trade is heavily influenced, if not dominated, by governments, it is patently ridiculous to say that the U.S. government will play no role. The famous Carter grain embargo against Russia in 1980 proved government action in the name of foreign policy can be as disruptive and politically unpalatable as short-supply grain embargoes.

The commodity groups, as expected, want the best of all worlds. On one hand, they want government export credit, government power to increase market access and government action to stop other countries from acting "unfairly" in international markets. At the same time, they lead the crusade to end government "interference" in international markets. Of course, one group's "interference" is another's preferred policy for a number of political and economic reasons.

Because of the new participants in the policy process and the economic and political complexity of the new international issues, I believe there will be more violent and prolonged political battles over the proper role of government in international commodity policy. When one considers the importance and interrelations of the two major issues, domestic price stability and the role of government in

international markets, it is easy to predict that they will not be settled quickly nor easily.

Agricultural Economists and Commodity Policy

The agricultural commodity policies of the 1930s were developed in large part by professional agricultural economists, many of whom have been rightfully honored by this association. In the post-World War II period, however, the majority of professional agricultural economists developed a singular disdain for commodity policy, abandoning it for resource policy and development policy among others. Only a few members of our profession continued to pursue the problems of commodity policy.

As one who has been involved in the confusing and somewhat painful transition to the new international policy, I have been surprised and concerned at how little our profession has to contribute to discussions of the new issues and problems that face the United States.

Ours is a discipline that has espoused the greater use of markets, but it turns out that professionally we appear to understand little about how either domestic or international commodity markets really work. The burgeoning field of international commodity trade is dominated by business school graduates rather than agricultural economists, and some have gone so far as to suggest that training in economics, and especially agricultural economics, is a handicap to understanding commodity markets.

We have spent millions, if not hundreds of millions, of public and private money to build computer models. Few, if any, of these models have a satisfactory international component.

Equally disconcerting is the fact that as a profession we have little access to, and few working relationships with, many of the new actors on the policy scene. The profession's longstanding ties with the USDA are appreciably weaker than in the 1960s; and how often does the State Department, Office of the U.S. Trade Representative, Treasury, Commodity Futures Trading Commission, International Trade Commission, and other major agencies that influence commodity policy turn to the members of our profession for analysis and advice? In my recent experience, not often, and probably for good reason.

It is ironic that at a time when there is a need for a greater understanding of the broad relationships of macroeconomics to agricultural commodity markets, the group which should be well-trained and prepared to deal with such issues is so little used and has little to offer. I would guess that there are more professionals engaged in buying and selling agricultural commodities on world markets than ever before in history, and more professionals developing and analyzing government commodity policy around the world than ever before, and that the proportion of them trained in agricultural economics is the lowest ever.

Again, I have no specific suggestions to reduce the widening gap between what I believe will be the major economic political problems in commodity policy and the professional focus of agricultural economists. I think this gap is not healthy for either good policy or a strong profession.

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Agricultural Economics in an Evolutionary Perspective

Kenneth E. Boulding

The search for an evolutionary perspective in economics goes back a long way. I have argued, indeed, that Adam Smith was the first evolutionary economist, that Malthus was the second, and that it was no accident that Darwin got his idea of natural selection when he was reading Malthus one evening "for amusement" (p. 120). The search for an evolutionary perspective is a search for a model which will enable us to perceive structure and pattern in the great ongoing flux of the universe through space and time.

The evolutionary "vision," which is perhaps a better word for it than "model," is a way of looking at an enormously complex universe, rather than an explicit model of a simpler reality. It sees the evolution of the universe as a process of constant ecological interaction under continually changing parameters. At any one moment the universe is a set with a large number of populations of different species. A population is a set of elements which are alike enough to be interesting, though they may not be identical in form and structure. A species is anything which has a population. It may include subatomic particles, photons and electrons, chemical atoms, molecules, DNA and genetic structures, cells, organisms, human beings, ideas, words, commodities, securities, money, and so on. The population of any species grows by additions and declines by subtractions. Additions may come from the formation of elements, from chemical reaction, as when hydrogen combines with oxygen to produce H_2O, from replications as with DNA, from births in the case of organisms, from the growth of seeds and plants, from the learning of know-how or know-what, from the production of human artifacts and goods, and so on. Subtractions come from such things as atomic fission, which destroys elements; the disassociation of chemical compounds; the disintegration or mutation of DNA; the death of organisms; the forgetting of learned structures; the consumption of commodities; and so on.

A population grows if additions exceed subtractions, and declines if subtractions exceed additions. If it declines far enough, it becomes extinct and is reduced to zero. In any one population the additions and subtractions will be functions of all other populations of species around it that constitute its environment. Some of these will have favorable effects and make the population grow; others will have unfavorable effects and make it decline. For any population in a given environment we can postulate that it will have an equilibrium level at which additions equal subtractions and the population neither grows nor declines. If this equilibrium is to be stable, then at a population lower than the equilibrium level, it must increase; above the equilibrium level, it must diminish.

In a given habitat we can postulate an ecological equilibrium in which all interacting populations are in equilibrium. Each population is at a level at which, on the whole, it is neither rising nor falling. An equilibrium population may be called a "niche" in such a system. This is a term used rather loosely by ecologists, but the above definition seems to be most meaningful.

The ecological interaction which creates niches is "selection." It is a very complex process. Darwin's "struggle for existence" is a most unfortunate metaphor. Actually ecological interaction involves very little struggle. Most of it is completely unconscious. There are three major types of such interaction. First, cooperative or symbiotic interaction in which an increase in population A produces an increase in the equilibrium value of population B, and vice versa. There is mutually competitive interaction in which an increase in population A produces a diminution in the equilibrium value of population B, and vice versa.

Invited address.

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Then there is a mixed relationship characterized, for instance, by predation or parasitism, in which an increase in A, a predator, diminishes the equilibrium population of B, but an increase in the population of B increases the population of A. There are limiting cases here of indifference. Thus, an increase in A might increase or decrease B, but an increase in B may not affect A at all. This happens sometimes when A is a dominant species.

Ecological equilibrium is, of course, a mental construct. It is probably never found in nature, although it is a useful concept because it does interpret the dynamics of ecosystems as they may be approaching an equilibrium. The equilibrium position, however, is a function of the parameters of the system and these parameters are constantly changing. This is mutation. The change may be in physical parameters such as temperature, as when the earth warms up or cools off in a succession of ice ages. There may be changes in material population such as soils and soil components which erode. There may be atmospheric changes following eruptions or the impact of an asteroid—such an impact is supposed to have exterminated the dinosaurs. Then there are genetic changes which create new biological species. A change in a single parameter of an ecological system may change the niches of all populations in it. This is the great ecological principle that everything depends on everything else.

In order to complete the model, two further concepts must be developed. The first is that of the "empty niche"—that is, the population which would have a niche in an ecosystem if it existed. Thus, in the nineteenth century there was clearly an empty niche in Australia both for rabbits and for European-type humans. Once they were introduced, they expanded rapidly into the niche. The filling of an empty niche, however, changes all the existing niches in the system and, indeed, the system of empty niches itself. The introduction of rabbits into Australia probably diminished many populations of indigenous species. It also created an empty niche for the organism which produces myxomatosis, a disease of rabbits. When this was introduced, the niche for rabbits shrank. A constant ecological ballet is going on, therefore, all the time, with empty niches being filled, parameters changing, and the niche structure changing. This is evolution. If there is such a thing as a final ecological equilibrium, it is a very long way off and we know nothing about it. The universe is a disequilibrium system and has been from the very beginning.

The second important concept is that of production, a special form of addition to populations, which rises to prominence with the development of DNA and of life and the distinction which then develops between the genotype and the phenotype, the egg and the chicken. Production is the process by which a genotype is transformed into a phenotype. It is not of great significance in pre-biological evolution of physical and chemical species. The phenomenon of catalysis, the role of which in physical and chemical evolution is still largely unknown, is in some sense a precursor of genetic structure in the sense that the catalyst has a structure which imposes its own patterns on its physical and chemical environment.

With the development of DNA, however, the distinction between the genotype and the phenotype becomes very important. DNA has two remarkable properties: the first is that of self-reproduction (I have sometimes called it "the first three-dimensional xerox machine"); second, its property of "know-how"—that is, its ability to organize the production of a phenotype. We see this in a primitive form in asexual reproduction as each half of a divided cell is able to grow into a complete cell because each half contains the essential genetic information which organizes its growth. We see it spectacularly in sexual reproduction, where a fertilized egg has the capacity of growing into a member of the phenotype species which produced it and hence creates an addition to the species population.

Production, then, is the process by which the genotype becomes the phenotype. It starts off with the genetic factor, which is the "know-how." In order for this know-how to be realized, however, there has to be a sufficient amount of the "limiting factors," which can be classified roughly as energy, materials, space, and time. A fertilized egg must be able to capture energy for at least three purposes: to transport and transform selected materials into the growing organism, to sustain the temperatures at which these transformations can take place, and to convey information which selects the materials. The right materials must also be available. There must be space in which these processes can be carried out. And there must be time for them to be carried out. For all the limiting factors there is

some minimum below which the potential for growth of the fertilized egg into a phenotype cannot be realized. If there is not enough energy of the appropriate kinds, if there is a deficiency even in a single material which is necessary, if there is not enough space, if there is not enough time, the growing phenotype will die before it matures and the fertilized egg will not contribute to the perpetuation of the species.

These concepts apply with suitable modifications to the evolution of social systems, just as they do to biological systems. With the biological development of the human race, an extraordinarily new evolutionary factor was introduced because of the remarkable capacity of this organism for developing both "know-what" and "know-how." No previous organism had anything remotely like the capacity of the human race for developing cognitive and valuational structures within its nervous systems. Humans can form images in their minds which correspond in considerable degree, not only with the whole human environment, but also which have the capacity of visualizing changes in this environment and carrying out these images of change in the production of human artifacts. Human artifacts comprise material artifacts, from flint knives to space shuttles; organizational artifacts, from the hunting band to NASA; and personal artifacts—that is, human beings with learned structures within them derived from other human beings.

With the development of the human race, evolution on our planet becomes increasingly what I have called "noogenetic." Even in prehuman evolution, a distinction between the purely biogenetic—that is, DNA and all that—and the noogenetic—that is, learned structures transmitted from one generation to the next by a learning process—has increasing significance. With the advent of the human race, however, noogenetic evolution becomes of overwhelming importance. In human beings the biogenetic evolution seems virtually to have ceased, at least in the last 50,000 years, and the biological gene pool of the human race has changed very little. In terms of human artifacts—material, organizational, and personal—however, the impact has been enormous. No part of the world ecosystem has been unaffected by it—cities, highways, agriculture, airplanes, chemicals—by this time hundreds of thousands of species of human artifacts have transformed the whole ecosystem of the earth, in what by biological standards is a fantastically short space of time. Many biological species have become extinct or are on the way to extinction; others may be on the way to creation, with the potentiality now for human beings intervening in the biogenetic structure.

Human artifacts are as much a part of the ecological system of the earth as are biological artifacts. They consist of populations of species interacting both with other human artifacts and with biological species. Even paleolithic humans created large-scale biological extinctions. With the development of agriculture and the neolithic, considerable changes in the recombinations and selection process of biological species (crops, livestock) took place. With the discovery of the use of fire, the input of organized energy into the system was increased enormously, with the subsequent development of cooking, pottery, metals, and a great variety of new artifacts. The rise of science in the last 500 years has created a positive explosion of new artifacts—chemicals, radioactive elements, machines, airplanes, computers, and so on.

The pattern of mutation (filling empty niches) applies just as much to human artifacts as to biological organisms. The niches for human artifacts are created to a very large extent by human demands and valuations. Whether these niches are filled depends on the changes in the noogenetic structure—that is, in the know-what and the know-how of the human race.

The production of human artifacts differs from that of biological organisms only in the complexity of the genetic structures. Biological evolution never got much beyond two sexes. The evolution of human artifacts is essentially "multi-parental." It involves the bringing together of know-how from a great many different sources. Human artifacts differ from biological organisms also in that their genetic structure is not contained in the artifacts themselves, but in other artifacts. The know-how that enables animals to reproduce is contained in the animals themselves. The know-how that permits the production of automobiles is not contained in the automobile, but in human beings and in plans, blueprints, libraries, and all the various prosthetic devices of human knowledge.

Nevertheless, the principle that production consists of the process by which the genotype becomes the phenotype is just as applicable to

human artifacts as to biological organisms. Although production originates in the genetic factor of know-how, it requires limiting factors of energy, materials, space, and time. If these limiting factors are not available in sufficient quantities, the potential for know-how will not be realized. An increase in know-how, however, can often push back the limits of the limiting factors, and indeed has done so constantly, both in biological evolution and in societal evolution. Prior genetic mutation through history permitted the biosphere to utilize forms of energy and materials which previously it could not utilize. In societal evolution, likewise, the growth of human knowledge and know-how has permitted a continual expansion of the niche of the human race and of its artifacts, by developing new forms of energy use, new materials, space-economizing and time-economizing techniques, and so on.

What does all this mean for economics, and especially for agricultural economics? Economics, I have sometimes argued, is the third oldest of the sciences, after physics and astronomy. Its theoretical structure crystalized in Adam Smith; it has not basically changed much since. Adam Smith had a clear concept of the system of commodities as an equilibrium system of quantities and prices, the equilibrium price system being that at which each commodity existed in an equilibrium population in which production and consumption were equal. Malthus applied this idea with particular cogency to what today we would call the concept of the "human niche." Both Adam Smith and Malthus were interested in development; that is, changes in the parameters of the system which increased its variety and complexity. It arose fundamentally, as Adam Smith saw, from the "quantity of science"; that is, human knowledge and know-how. In some sense, therefore, Adam Smith was the first in the scientific community to transcend a Newtonian equilibrium and to see the social system at least as an ongoing evolutionary process. He did not apply this to biological systems, for in his time, for instance in his contemporary Linnaeus, biology was only in the stage of achieving taxonomy, and did not develop any serious theoretical structures.

Unfortunately, Adam Smith, after the first three chapters of *The Wealth of Nations,* never developed his extraordinary insights regarding the impact of the division of labor on human learning and the essential role of human learning in production. We may perhaps blame the historical accident of structure of British agriculture in the eighteenth century, with its rather clear categories of landlords renting land to entrepreneurial capital-owning farmers employing landless capitalist laborers, for creating the taxonomy of factors of production as land, labor, and capital. In terms of the price system, this taxonomy has much value. Rent, profit, and wages do emerge as categories of some homogeneity and great interest from the point of view of distributional theory.

Who originally used the term "factors of production" and identified these as land, labor, and capital, I must confess I have not investigated. The concept, however, was formalized by Ricardo and became part of mainline economics under Mill. Marshall was never able to escape from this, although he tried to add a fourth factor, "organization," which he never quite identified as "know-how." Marshall was clearly uneasy about the Newtonian quality of equilibrium economics and felt that economics should use biological rather than mechanical models. He was never able to achieve this transition. Walras, unfortunately, by formalizing mathematically the mechanical aspects of general equilibrium, pushed economics into a still more Newtonian model. Keynes, again, never escaped from the equilibrium trap, and the supposedly developmental economics of Harrod and Domar can only be described as a disaster. It is totally incapable of illuminating the enormous complexity of developmental processes and leads to a neglect of the major element in them, which is the learning process.

The greatest disaster of all, of course, was Marx, whose labor theory of production must be blamed mainly on Ricardo, although Adam Smith is not blameless. It has been a major disaster for the human race and has created an evolutionary dead end in the communist societies, which bodes ill for the future. Marx, however, learning from Ricardo, at least saw the existing stock of human artifacts as the end product of innumerable acts of human labor, stretching back presumably to Adam and Eve. This was at least a primitive evolutionary perspective, seeing the present as a result of the history of the past. But as both Ricardo and Marx predated Darwin, and even Darwin knew very little about genetics, ecology, or morphogenesis, they can hardly be blamed for being primitive.

Both Ricardo and Marx missed the crucial

point which Adam Smith had begun to see, that it is human knowledge and know-how which is the real genetic factor, not "labor," which from the point of view of production is a hopelessly heterogenous aggregate. I have argued, indeed, that land, labor, and capital, from the point of view of the theory of production, are medieval aggregates with all the scientific validity of earth, air, fire, and water, and that they represent a totally inadequate taxonomy of the production process and of the evolutionary process. Once we look at production from the point of view of one genetic factor, know-how, and a set of limiting factors which may limit its operation, the whole process looks very different.

Another disaster was the development of what I have sometimes called the "cookbook theory" of production, in which Wicksteed, Walras, John Bates Clark, and so on, removed even the vestiges of Adam Smith's essentially evolutionary thought from economics. Here production has no history whatever. It consists of mixing land, labor, and capital in a cooking pot and out come potatoes or automobiles. The whole concept of a production function involving heterogenous aggregates of land, labor, and capital is pure economic alchemy and has been a total blind alley. The more sophisticated the theory of production got from Cobb-Douglas to constant elasticity of substitution production functions, the more useless it became, simply because it started off with a false taxonomy. No matter how elegant alchemy becomes, it will never produce synthetic plastics!

A further result of the cookbook theory of production was an almost total neglect of the problem of exhaustible resources. The ingredients were somehow always assumed to be in the kitchen—a kitchen, indeed, full of inexhaustible widow's cruses of land, labor, and capital, all willing to be poured into the cooking pot. It almost took the OPEC crisis of 1973 to awaken us to the fact that our boasted riches and productivity depended in no small measure on the exhaustion of exhaustible resources, not only in energy but also in materials.

The implications of the evolutionary perspective for agricultural economics could well be profound. In the first place, agriculture is the one sector of economic life which is inescapably close to the biological processes and in which, therefore, the relations between biological and societal evolution are of particular importance. Agriculture indeed consists of the application of human knowledge and know-how to changing the parameters of ecosystems in particular habitats in order to create a new quasi-equilibrium set of largely biological populations which is higher on the scale of human values. In other words, the business of agriculture is to transform an ecosystem so that it produces wheat instead of brambles, fat cattle instead of starving deer, sheep and pigs instead of buffalo and coyotes, thereby increasing the niche of the human race. This process involves a combination of noogenetic intervention, working through biogenetic processes. Up to now the impact of the noogenetic process has mainly been on selection, creating ecosystems with high populations of things high on the scale of human values, like food. To agriculture, of course, we should also add silviculture and the transformation of forest ecosystems and aquaculture, by which human know-how transforms the ecosystems of ponds, lakes, and rivers.

The parametric change which is introduced into these ecosystems by human intervention is complex and often produces unexpected results. Plowing rearranges the materials in the soil to make it more favorable to the growth of desired plants, but also may lead to soil erosion. Artificial fertilizers have pushed back some of the limiting factors of the materials affecting plant growth, but may also pollute streams and rivers. New seeds, hybridization, increase yields per acre by pushing back the space limitation, but through monoculture may increase the dangers of ecological disaster through exposure to new pests and diseases. An important aspect of humanly created ecosystems that is often neglected is their vulnerability to uncontrolled parametric change. The Irish potato famine of the 1840s was a classic example of an agricultural improvement which led to human catastrophe through vulnerability. One worries a bit about what might happen in the United States if we had a combination of a corn blight, a wheat rust, and a soy beetle all in the same year!

It is clear that agriculture must be regarded as part of the general evolutionary process of the planet, which has profoundly changed its aspect and its ecosystems, mainly through selection, in response to human valuations. We may indeed be on the edge of even more dramatic changes as a result of our potentiality for intervening in genetic as well as selective processes, through recombinant DNA, and

eventually, who knows, through chemical reconstructions of DNA. As a result, we may speed up biological evolution to an unprecedented rate. It is a very important question as to whether this may not make the whole system of the earth more vulnerable than it has been in the past. One of the remarkable phenomena in the evolution of this planet has been the capacity of the process to survive, and indeed even in some sense benefit from, catastrophe. If the record of the rocks is to be trusted—which it is not very much—the evolutionary process has been punctuated by catastrophes which separate one geologic age from the next. These catastrophes seem to have led to widespread extinction of the species of the previous age, which apparently opened up new niches, almost always for more advanced species, at least by human standards. Exactly why this should be so is by no means clear.

The evolutionary perspective in economics does not give us a Newtonian "celestial mechanics" of commodities; and this is because of the nature of the reality itself, which it is trying to describe, which is profoundly indeterministic. Evolution takes place by the filling of empty niches. There is no guarantee that empty niches will be filled before they close. This introduces a profound element of indeterminacy into the system, and any attempt to reduce it to a kind of Newtonian mechanics is bound to fail, simply because it is not that kind of reality. This is why, for instance, empirical attempts to explain development in terms of land, labor, and capital production functions have been so unsuccessful. We have always had to fall back on some vague concept of technological change, which is a kind of surrogate for the genetic know-how factor.

Agriculture is peculiarly important in the development of society because of the capacity for improvements in agriculture to create empty niches in many other fields and even to increase the capacity for filling existing empty niches. A good example would be what I have sometimes called the "turnip theory" of Western European, especially British, expansion in the last 200 or 300 years. The introduction of the turnip into Western European, and especially into British, agriculture in the early part of the eighteenth century, transformed the medieval three-field system into a four-course rotation. Turnips and other root crops enabled the previously fallow field to be used. The main reason for having the fallow field in medieval agriculture was to get rid of the weeds. With row crops and horse hoeing husbandry this could be done and still have a crop. Furthermore, clover could be introduced to restore fertility. This substantially increased the overall yield per acre, particularly in livestock feed. This permitted livestock to be kept through the winter instead of having to be slaughtered off at Christmas. This permitted breeding and improvement of livestock. This increased human protein consumption, which led to a diminution in infant mortality that was spectacular, especially in Britain in the mid-eighteenth century. This led to a population explosion which previous improvements in ocean transportation spread around the world to Australasia, North America, and South Africa. This created empty niches for new industrial production and so on to the present day.

An increase in yield per acre in agriculture will increase the size of the human niche, but an increase in yield per worker, because of the relative income inelasticity of the demand for food, diminishes the proportion of the population in agriculture, and expands the niches for nonagricultural goods. The filling of each new empty niche by invention (for instance, in textiles or in machinery) opened up new niches elsewhere, which again had repercussions in agriculture. Thus, the exhaustion of whale oil in the mid-nineteenth century due to the overkilling of whales opened up a niche for kerosene. It is not surprising, therefore, that the oil industry started in 1858. The development of chemistry permitted the transformation of crude oil into kerosene and gasoline, which at first was an unwanted byproduct. This created an empty niche for the internal combustion engine and the automobile, which in turn created empty niches for highways, the cement industry, supermarkets, and shopping centers. This also fed back into agriculture through the tractor and the substitution of fossil fuels and energy for horses, which released further food supply and led to further increases in the output per person, to the point where now in the rich countries something between 4% and 10% of the population produces all the food that is consumed, leaving 90% for other things. Only 200 years ago, food production took 80% or 90%, leaving only 10% or 20% for other things.

What then does this evolutionary perspective imply for the future of agricultural eco-

nomics? If there is indeed an empty niche, as I hope, for a genuinely post-Newtonian evolutionary economics, it seems reasonable to look to agricultural economics, with its rich biological involvement and its long tradition of both empirical and applied research, to pioneer in this development. This may mean the abandonment of some degree of mathematical rigor, which easily turns into rigor mortis when the real world that is being investigated is not itself mathematically rigorous and has large elements in it of randomness and unpredictable parametric change. This is not to defend sloppy thinking, casual empiricism, or merely analogical reasoning. Models, however, must be appropriate to the system that they attempt to describe, and there is a great opportunity here for the development of a mathematics which is appropriate to evolutionary reality. If the theory of fuzzy sets can be expanded into a theory of fuzzy processes, we may be much closer to the real world than we are when we try to find stable parameters which do not exist in nature. A symbolic representation of evolutionary reality in a simplified manner is very much needed and should be a real challenge to the mathematicians, for the mathematics which is really appropriate to evolutionary and to social systems does not yet exist. The social sciences in the twentieth century have been captured by essentially seventeenth-century mathematics, with a little dash of nineteenth-century probability and statistics, much of which is quite inappropriate to the type of real world which is being investigated.

Agricultural economics strikes me as being the ideal starting point for empirical investigation into both limiting-factor models and exhaustible-factor models, both aspects of what might be called "genetic production theory." It is obvious in agriculture that human know-how has been the critical factor in agricultural production. This know-how, however, is limited in its realization by the limiting factors of energy, materials, space and time, but is also constantly engaged in pushing back these limits. An important aspect of limiting-factor theory is that it is the most limiting factor which is important. If we are climbing a mountain, even if it is a utility mountain, it is the first fence that we come to that stops us. Other fences might lie beyond this and if we push back the first fence they may become the most important, but at any one time it is the first limiting factor that demands the major part of our attention.

An increase in the know-how or genetic factor, of course, may change all the limiting factors, for they all interact with each other. Hybrid corn, for instance, certainly economized space. It also economized time, being quicker and easier to harvest. It may even have economized energy input, utilizing more solar energy and less muscle or fossil fuel power, but I am not sure of this. It probably did not economize materials, but increased the necessity for artificial fertilizers. What we have here is a complex shift in the fences that crisscross the productivity hill. They are by no means easy to unscramble. Unscrambling these effects would be much more rewarding than trying to develop Cobb-Douglas production functions, or any kind of constant parameter function. Sometimes, indeed, the most important limiting factor could be an undetected trace element.

Another large field of research which opens up is the study of the impact of relative price structures, particularly of their certainty and uncertainty on agriculture. The relative price structure operates through wages, prices, profits, and rents. Its impact on production is mediated through its impact on the limiting factors. Yet this is something which the cookbook theory of production completely overlooks. Labor is a complex aggregate of know-how, muscular energy released through the burning of food, material structures that determine health and vigor, diet and nutrition. In Adam Smith, and oddly enough even in Jevons, labor was a kind of input-output apparatus to transform food into other things. Feeding agricultural workers produced more food. Feeding industrial workers transformed food into textiles or metals or machines, if the laborer was employed in these areas, very much in the way that a cow was an input-output machine for turning grass into milk and meat. This at least was closer to the complexity of the real world than the assumption that labor was an independent measurable factor of production, which when stirred in with capital and land became cheese. The opportunities for empirical research guided by the limiting-factor theory seem to me to be very great.

Finally, agricultural economics is an excellent field for the study of the economy as a subset of the larger evolutionary ecosystem of the world, particularly for what I have been calling "echo effects." If agricultural economics cannot be part of a general ecological science, there is not much hope for us. Ecological systems are also "echo systems," in which

any act or event echoes and re-echoes all over the system, and the final effect may be extremely different from the initial disturbance. We see this particularly in the problem of distributions of economic welfare, which often end up very far from an initial intended act. Agricultural policy is an extraordinary case in point, where, for instance, price supports that originally were conceived to help the poor in fact have helped the rich farmer and chased the poor farmer out of agriculture, perhaps—or perhaps not—to be better off elsewhere. Such policies have benefited the nonagricultural population much more than the agricultural population, have created all sorts of strange redistributions among the owners of land, like the impact of the tobacco quota, and have ended up with a very different kind of overall ecosystem than their authors imagined. Agriculture is also a good example of a reverberant system, where the echoes do not die away but set the system on a course of irreversible evolutionary change.

It is a fundamental principle of evolutionary theory that our capacity for predicting the future is extremely limited. Celestial mechanics had only the success that it had in predicting eclipses because the evolution of the solar system had virtually ceased. Agricultural economics deals with one of the most significant and rapid evolutionary systems in the world and should, therefore, be skeptical of prediction of any kind. Nevertheless, it does lead us to the search for empty niches and for the possibilities of filling them, and this may be a much more important guide to policy and to human behavior than mechanical prediction. The guide to societal evolution is search, both historically and in work on the future. Agricultural economics has a peculiar opportunity to study and improve the process of search for empty niches and for new mutations. Newtonian economics may have come to a dead end. But every evolutionary dead end seems to have created a search for an open road, and in this last reflection one can indulge in a good deal of hope and optimism. This is an age of Jeremiahs, quite legitimately, if we are confined to contemplating the future of the world as if it were not an evolutionary system. But the evolutionary model emphasizes the unexpectedness of the future, and in unexpectedness there is always hope.

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Funding for Agricultural Economics
(B. R. Eddleman, Mississippi State University, Presiding)

Funding for Agricultural Economics: Needs and Strategies for the 1980s

Bernard F. Stanton and Kenneth R. Farrell

Public funding for work in agricultural economics—teaching, research, and extension—appears to be declining in real terms at the start of the 1980s following two decades of real increases. There is a call for reductions in spending by government at all levels—a call for less taxes and for public accountability. At the same time there are more students in the courses that agricultural economists teach. There is a renewed interest in agricultural business curricula. Graduate study in agricultural economics is attracting new students from the biological and social sciences as well as agriculture. The demand for competent, applied economists, particularly agricultural economists with advanced degrees, appears to be growing.

The anomaly of apparent increases in demand coupled with declining public funding presents a challenge to the profession. It should be one for which economists are prepared. After all, we regularly teach students about economic decision rules for allocating scarce resources among competing ends. The political environment requires that we take our classroom lessons seriously and put them in practice in our own operations.

This paper explores several approaches and strategies for funding work in agricultural economics and more effective use of current resources. We begin with an overview of changes in funding during the decade of the 1970s drawing upon secondary data and results of a mail questionnaire sent to agricultural economics department chairmen and administrators in the spring of 1981. We turn, then, to discussion of the demand, current and prospective, for services of agricultural economists and the capacity of current institutions to service that demand. We conclude with discussion of funding strategies and recommendations on actions which might be pursued by the AAEA.

Overview of Funding in the 1970s

During the decade of the 1960s federal appropriations for agricultural research from all sources increased in real terms. In the 1970s, in contrast, they held roughly constant. Over the same time span total nonfederal support continued to rise in real terms. Most of this support was from state and local sources, but it also included small but significant increments from private foundations and industry groups. Although similar data are not readily available for extension and resident instruction and the relative proportions supplied by state and local versus federal sources is somewhat different, the same basic trends should hold with nonfederal sources providing an increasing share of the total in the 1970s.

In 1970 USDA had appropriations of $281 million, or 1.8% of total federal funding. In 1980 research at USDA was funded at $664 million, or 2.2% of the federal total. Relatively, agriculture gained in the 1970s along with other nonmilitary federal agencies as a smaller percentage went to defense and space.

Research Funding—CRIS Aggregates

Public sector expenditure for agricultural research is largely the work of either USDA or state experiment stations. In terms of 1979 dollars, funding for agricultural research increased by 27% during the past decade. Biological science accounted for about 70% of the total, physical science varied between 18% and 22% and social science the remaining 8%–12% (table 1).

When funding for research in agricultural economics was separated out of the totals for

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Table 1. Public Sector Expenditures for Agricultural Research (All Sources, CRIS Data, United States, 1970–79)

Year	Biological	Physical	Social and Other	Total
	(1979 $, millions)[a]			
1970	684	204	80	969
1972	716	216	91	1,023
1974	738	213	94	1,045
1976	773	229	117	1,119
1978	860	248	146	1,256
1979	885[b]	226	122	1,233

[a] Using the GNP Implicit Price Deflator.
[b] Preliminary.

social and behavioral sciences, there was an increase in the total (1979 dollars) of more than 45% during the decade, compared with 27% for all agricultural research. Thus, economics amounted to a little more than 6% of all agricultural research expenditures in the first half of the 1970s and over 7% in the last half (table 2).

A distribution of the funding of agricultural economics research by source is presented in table 3. In terms of 1979 dollars there were important increases in all of the sources listed in these unpublished CRIS data. USDA "in-house" funding for economics research increased about 50% in real terms. The Economic Research Service accounted for 69% of that total in 1970 and 75% at the end of the decade.

Agricultural economics research funds distributed to the state experiment stations by the USDA, both formula funds and all types of grants, contracts, and cooperative agreements increased modestly (27%) in real terms,

Table 2. Public Sector Expenditures for Agricultural Economics Research (All Sources, CRIS Data, United States, 1970–79)

Year	Expenditures current terms	Expenditures 1979 dollars[a]	Percent of total agricultural research
	($ millions)		
1970	35.8	63.8	6.6
1972	44.7	72.8	6.1
1974	50.8	72.0	6.9
1976	69.6	85.8	7.7
1977	74.4	86.6	7.1
1978	87.0	94.3	7.5
1979[b]	93.7	93.7	7.6

[a] Using the GNP Implicit Price Deflator.
[b] Preliminary.

Table 3. Sources of Funding for Agricultural Economics Research (Public Sector Expenditures, CRIS Data, United States, 1970–79)

Sources of Funds	1970	1976	1979
	(1979 $, millions)[a]		
USDA: (internal)			
Economic Research Service	21.1	30.5	33.1
Agricultural Research Service	2.3	2.2	3.2
Forest Service & Farmer Coop. Service	7.2	7.2	7.7
Total	30.6	39.9	44.0
USDA: (external)			
Cooperative research	12.6	16.4	14.6
Grants, contracts, agreements	1.2	1.5	2.9
Total	13.8	17.9	17.5
Other federal departments & agencies	2.3	6.0	7.1
Nonfederal	17.1	22.0	25.1
Total	63.8	85.8	93.7

[a] Using the GNP Implicit Price Deflator.

equivalent to the aggregate increase in the decade for all agricultural research. Agricultural economists at the state experiment stations and land grant universities turned increasingly to their own state governments and other federal agencies for funding during the decade. In 1970 federal agencies other than USDA accounted for only 3.6% of total funding but this increased to 7.6% of the total in 1979. Nonfederal sources increased by 47% over the period, the same rate as total research funding grew in real terms.

Information on Funding—Agricultural Economics Departments

A survey of chairmen of departments of agricultural economics was conducted using a mail questionnaire during the spring months of 1981. A total of fifty questionnaires were returned from 1890 and 1862 land grant universities and a few other departments with programs in agricultural economics. Comparative data were obtained from forty departments (table 4).

Agricultural economics departments have not fared particularly better or worse in funding than other academic departments in their respective colleges over the past decade. Agricultural economics had a larger budget relative to the rest of the agricultural college in 1980 compared to 1970 in eighteen cases but it was smaller in fifteen others. Changes in both directions were generally modest.

Departments were asked to allocate their

Table 4. Student Numbers: Agricultural Economics Departments (40 U.S. Universities, 1970 and 1980)

Region	Number of Schools	Number of Majors Advised 1970	1980
Undergraduate students:			
Northeast	7	708	1,290
North Central	9	1,806	2,962
South	14	1,091	2,546
West	10	1,416	2,481
Total	40	4,821	9,279
Graduate students:			
Northeast	7	187	239
North Central	9	654	776
South	14	375	675
West	10	234	353
Total	40	1,450	2,043

budgets to the three major functions of teaching, research, and extension, as well as international programs and note important changes in these distributions. Only modest changes in the percentage distributions occurred during the decade. The median allocations in 1980 were 47% for research, 24% for extension, 18% for teaching, and 11% for all other activities including international programs.

It is difficult to establish the percentage of time individual faculties spend on each function, such as teaching. The numerical data on the changes in student numbers advised by agricultural economists at the forty colleges and universities indicate a substantial increase in the teaching commitment over the decade, even though the percentage allocations to teaching do not fully reflect this. In all of the regions undergraduate numbers increased significantly. The number nearly doubled nationally, with the largest percentage increase in the fourteen departments in the South. Every department reported an increase in undergraduate majors. The increase in graduate student numbers during the decade was also substantial, a little over 40% nationally. It is likely that resources from these commitments have been "borrowed" from research.

In terms of sources of budget support for all the programs and functions of individual departments, state resources are the primary source of funding, on the average, in all of the regions. Funds allocated to departments from the USDA were a smaller part of the total budgets in all regions, dropping from 34% to 28% nationally. Other federal agencies and departments provided some of the added support from grants, contracts, and other types of agreements.

Funding for research is more completely documented than for extension or teaching. Departments nationally obtained 45% of their funding from state sources in 1970, compared with 43% in 1980. USDA formula funds and grants also decreased from 42% of the total in 1970 to 38% in 1980. Other federal agencies, which accounted for 7% of research funding in 1970, provided 14% in 1980. Energy, natural resources, transportation, international development, and environmental protection were the chief sources of this support. Only limited funding, less than 0.7% in 1980, came from the National Science Foundation (table 5).

Respondents were asked to allocate funding for research into five general areas of work in agricultural economics in both 1970 and 1980. In the Northeast there was a marked swing away from marketing and farm management to natural resource economics and land use issues. In the North Central region, marketing and prices and supply-demand analyses were the most important general areas of work in both 1970 and 1980. In this region alone, marketing did not show a decline in relative importance. In the South farm management and

Table 5. Changes in Sources of Budget Support: Research, Extension, Resident Instruction (40 Departments of Agricultural Economics, 1970 and 1980)

Region	Source of Budget	1970	1980	Net Change
		--- (% of total) ---		
Northeast	State	56	62	+6
	USDA	38	30	−8
	Other federal	2	2	0
	All other	4	6	+2
North Central	State	60	58	−2
	USDA	28	25	−3
	Other federal	7	11	+4
	All other	5	6	+1
South	State	53	54	+1
	USDA	42	36	−6
	Other federal	2	9	+7
	All other	3	1	−2
West	State	65	63	−2
	USDA	25	20	−5
	Other federal	6	14	+8
	All other	4	3	−1
Total	State	58	58	0
	USDA	34	28	−6
	Other federal	5	9	+4
	All other	3	5	+2

production economics increased in importance over the decade. In the West there was a major shift away from marketing toward natural resources and farm management.

Nationally, farm management and production economics held quite steady over the decade as a major research area. Marketing received less of the research resources, and there was an important shift in work toward land use issues, rural development, and natural resource economics in all of the regions. In a relative sense the increase in work in agricultural policy, regional economics, and macroeconomic issues was also of special note.

During the past decade agricultural economists have increased their participation in both research and extension projects involving scientists in other agricultural disciplines. This is true across all the regions and in most departments. In looking ahead, thirty-three of the department chairmen expected further increases in the amount of research involving other disciplines. Seven expected the amount to be roughly the same as now.

Setting of the 1980s

The foregoing data suggest that agricultural economics did as well or better than other agricultural science disciplines in competing for scarce resources in the 1970s. And there is evidence of adaptability and resiliency of the profession with respect to both sources of funding and subject matter emphasis.

Demand for Services

At the risk of appearing self-serving, we believe that aggregate demand for services of agricultural economists will continue to expand in the 1980s. However, the composition of that demand may change dramatically.

Our optimism with respect to growth in demand for agricultural economic services is predicated upon the expectation that food, agriculture, and natural resources will occupy critical roles in economic systems both in the United States and abroad during and beyond the 1980s. Food production, even in the United States, cannot be taken for granted as multiple use competition for natural resources intensifies.

Commercial production, marketing, and distribution of food and fiber have always been and still are the cornerstone of agricultural research and education programs (70% of total research). If the evolution toward less direct intervention by government in the agricultural economy continues in the 1980s, as now seems apparent, the private sector demand for timely, reliable, market-related economic information is likely to increase substantially. In the public sector, demand for economic information will continue strong as a basis for monitoring performance of the food and fiber system, policy analysis, and for targeting and evaluating public programs.

Our international interdependence also will be a source of continuing demand for economic information, research, and analysis in both the public and private sectors. Issues related to trade policy, food security, international market instability, market development, the organization and performance of international monetary and financial institutions, and the interdependence among trade and domestic food and agricultural policies are key areas likely to require additional attention of agricultural economists, particularly in the public sector. The private sector will require from corporate economists and from those in the public sector more detailed and specific data and analyses to guide market development and foreign investment activities.

We expect American agricultural economists to continue to be called upon for technical assistance and "institution building" in the developing countries of the world. For many of those countries, agriculture is the "cornerstone" of economic development. Heavily affected as many have been by petroleum price increases and a large foreign debt-servicing load, most developing countries face critical economic choices involving food and agriculture.

The major onus of responsibility for development of economic information, research, and policy analysis concerning natural resources rests in the public sector. That is not to say that the private sector is unaware of, unconcerned with, or without need for relevant economic information concerning the economics of natural resource use but merely to remind that market forces that drive many of the "on-site" decisions concerning natural resource use fail to capture externalities associated with those decisions. With much of the "slack" already removed from the U.S. agricultural production plant, we know much less than we should about the characteristics

of the long-run supply functions for land and water and the associated conservation, environmental impacts, and costs under conditions of sustained increases in agricultural production.

Department chairmen and administrators were asked in our survey to indicate the most important areas toward which additional work in agricultural economics should be directed in the 1980s. These judgments provide further insight into areas of work where increased demands seem evident.

(*a*) 39% suggested commercial agricultural production and marketing as areas requiring additional work.

(*b*) 22% identified agricultural policy and structure issues as highest priority.

(*c*) 19% identified with energy and natural resource issues.

(*d*) For the remaining 20%, undergraduate teaching programs and international trade and development were about equally distributed.

A wide range of specific problem areas were listed as most likely to require increased work by agricultural economists with scientists in other disciplines. Most frequently these were problems involving some aspect of production economics. Commonly, there was an energy-related component of the problems. Resource management issues, particularly about land and water, were high on many lists. A wide range of environmental concerns from integrated pest management to acid rain were noted.

Strikingly, not a single department chairman or administrator indicated that rural development should be given high priority. Whatever the future may hold for funding of rural development, it clearly is an area in which the application of economics should be highly relevant and to which agricultural economists have the capability to contribute, given their considerable talents in relating "economic theory to observable facts" and their knowledge of rural institutions. Surely agricultural economists, as social scientists, have a unique responsibility to understand and assist in the resolution of economic problems of people and institutions in rural areas.

Structure and Organization for Delivery of Services

tor continues as the major source of employment, economic data, situation and outlook information, and basic economic analyses. As an integral part of the USDA-land grant partnership fashioned in the late 19th century and tailored to its present institutional form in the first third of the 20th century, the public agricultural economics "establishment" of today bears many of the same strengths and deficiencies as the larger system. Several of the characteristics are worth noting as we reflect on needs, priorities, and funding of the 1980s.

Decentralization. Institutionally, public sector agricultural economics work is conducted in sixty-four land grant universities (fifty "1862" and fourteen "1890"), about fifteen other state universities and colleges, the federal government (primarily USDA), most state governments, perhaps ten to twelve nonprofit research and education institutions, and a few private universities. This decentralization of work is in many ways a strength of the establishment, tending to encourage responsiveness to local needs, independence, and intellectual freedom, and precluding singular, authoritarian dogma in theory and methods. But in other respects it complicates communication and coordination, contributes to duplication of effort, and inhibits development and implementation of concerted, discipline-wide initiatives.

Specialization. In most universities and in the USDA, agricultural economists have been most commonly grouped in units or departments that center around the discipline of economics. The disciplinary organization of our work is not inconsistent with the view of agricultural economics as an "integrating science." And, it has permitted us to develop theory, methods, comprehensive data sets, and a macroview of agriculture which might not have been achieved otherwise. At the same time, there has been a tendency for isolation from other disciplines and "problem-oriented" agricultural departments and units. That tendency inhibits interdisciplinary, mission-oriented research of the type needed to resolve many of the problems of the 1980s.

Pluralism. The "establishment" is diverse and pluralistic in mission, goals, methods, and funding sources. Most land grant departments

to each function. University programs emphasize state and local issues: USDA programs have a national and international focus. Research in universities is small in scale, heavily supported by graduate students, and oriented to the discipline, methodology, and longer-run problems. USDA research tends to be heavily applied, larger in scale, short-run, sometimes "crisis" oriented, with greater emphasis on policy analysis and primary data collection.

Again, there are strengths and benefits from pluralism. But these same strengths make it difficult to obtain clear national or disciplinary focus on programs, specify priorities or develop system-wide strategies.

Strategies for Funding and Problem Solving in the 1980s

Several indicators of tighter funding for agricultural economics work in the 1980s could be cited. As a proportion of college budgets, funding for agricultural economics during the 1970s declined in fifteen of the thirty-three departments responding to our survey. In late 1980, Michigan State University was forced to furlough staff and severely restrict support services as a result of falling state revenues. Other states have been similarly, if less drastically, affected by "proposition 13"-type reductions in state revenue. At the federal level, the Reagan administration has proposed sharp reductions or smaller-than-expected increases in budgets for many nondefense-related functions and departments. To bring matters "closer to home," the Reagan administration has proposed to reduce National Science Foundation grants for social, economic, and behavioral research from $49 million in 1981 to $16 million in 1982. The *Washington Post* reported that "OMB Director David A. Stockman and others have complained for years that social sciences produce little or nothing, and that their studies are often used to support liberal social programs." At the same time the *Post* reports, the administration has begun a "social science hour" at the White House to better understand the background social facts against which policy will be mapped.

Still "closer to home," ESS (now ERS and SRS) recently conducted a two-day public meeting to obtain suggestions for establishing priorities on statistics and economic research in ESS and activities which might be reduced or eliminated in the event that a 20% budget reduction were necessary in fiscal year 1983. Concurrently, the administration's budget proposals for fiscal year 1982 included increases for agricultural economic research as well as all agricultural research.

Although the funding levels for agricultural economics work for the immediate future are not yet clear, the direction toward tighter budgets and closer public accountability is evident. If, as we have suggested, demand for agricultural economics services continues to grow, we face difficult choices and the classical economic problem of allocating scarce, possibly scarcer, resources among competing uses.

Obviously, no single initiative or funding strategy will suffice. Each institution will need to develop plans and strategies adapted to its particular or unique circumstances with respect to clientele, priorities, and the quantity and quality of available resources. Nevertheless, there are several common and some multi-institutional or discipline-wide plans and strategies that warrant consideration and action.

Monitor Funding and Resource Allocation for Agricultural Economics Work on a Regional and National Basis

Communication within our decentralized system is difficult and highly imperfect. Yet, the availability of reliable, timely information is essential for planning and decision making. The need for such data is particularly important at this time when important decisions on funding and resource allocation may be taken in the context of tight budgets. These data are also essential for any informed, rational plan or strategy that might be undertaken subsequently by the profession or groups of professional institutions.

The CRIS is an embryo of a useful system for these purposes. It contains, however, superfluous information and is subject to excessive reporting lags. We suggest AAEA consider an annual survey of institutions having substantial resources devoted to agricultural economics, to obtain information on funding by functions and source and on allocation of resources by subject matter field. These data might be reported at the annual AAEA business meeting. The questionnaire developed for use in preparing this paper

could be a point of departure. The CSRS/USDA might be approached for funding assistance.

Initiate Efforts to Identify High Priority Research and Extension Needs for the 1980s

The profession has been loathe to undertake such efforts in the past. Certainly some of our past experiences, the pluralism of our work, and the reluctance of some leading figures and entrepreneurs in our profession make it a risky venture. However, the invitation of the director of USDA's Science and Education Administration to professional societies to develop a statement of priorities engendered a substantive statement from the AAEA Board in 1980–81. Greater involvement by more individuals in the profession should be fostered in future efforts.

To be useful and credible, a statement of priority needs must be more than a "laundry list" of what economists do or an amalgam of platitudinous wishes. It should be keyed from a careful, comprehensive review of likely directions of agriculture, natural resource use, and rural America in the 1980s; the principal data and research needs to which those trends give rise; and a sober assessment of our capacity to respond to such issues. It must avoid being self-serving or condescending in tone, and it must above all be rigorous and professional in content. With regional elaboration, one version could serve the profession as an indicative research planning tool. But a second version also is needed—one which is issue- and output-oriented, stressing decision makers to be served, and the value of output to those decision makers. Where appropriate, scientists from other disciplines should be involved in preparing these statements, especially the latter. Such statements should be updated and refined periodically to reflect changing needs and priorities.

Whatever approach is taken should involve the AAEA as an active participant. One approach might be for AAEA to "commission" a group of scholars nominated by the membership to draft the statement. Or, groups of scholars by subject matter field might be nominated to draft a series of statements to be integrated by another AAEA-appointed group. In any event, the statement should be the subject of written comments or conference dialogue by AAEA membership before final approval. Another variant would be to invite the regional associations to draft statements with a synthesis made nationally by AAEA. Recent prototypes of statements of this type include *Soil and Water Resources: Research Priorities for the Nation,* sponsored by ten professional societies including the AAEA, and *Animal Agriculture, Research to Meet Human Needs in the 21st Century,* sponsored by five professional societies, several experiment stations, and the USDA.

Assume a More Positive Stance in Funding of Agricultural Economics Work

Unless we are prepared to exert influence with those who make decisions on the funding of agricultural economics work, the development of improved information and statements of needs and priorities are of little avail, however elegant they may be in formulation and exposition. Other scientists have perceived this simple truth more readily than we. For example, the American Society of Animal Scientists has appeared on several occasions before SAES/USDA research planning entities to present consolidated statements on research needs and priorities on behalf of its membership. The land grant forestry schools and the U.S. Forest Service have worked closely over the past decade under aegis of the Joint Council and its predecessor organization to develop comprehensive statements on forestry research needs on regional and national bases. Those statements have been used consistently for development and presentation of budget proposals in the USDA, SAES, and before congressional committees with considerable success.

We know of no occasion in the past decade when a state agricultural economist has appeared before the House or Senate subcommittee on appropriations to support or comment upon the budget proposals of ERS or CSRS. Nor has the reverse occurred to our knowledge.

Direct support for agricultural economics research in the budget-making process is diffuse and weak. With the exception of ERS and CSRS, most budget proposals for economic research are "brokered" to appropriations bodies through deans or directors. Frequently those proposals are presented as "riders" to proposals from the physical and biological sciences where support may be higher. Typically, it is more difficult to convey the purpose and value of economic research to legislators

than for sciences in which output can be expressed in demonstrable physical terms. And, whereas farm and commodity organizations appear regularly before appropriations committees to support physical or biological science needs and proposals, few appear before such bodies in direct support of economic research. Even our statistician colleagues enjoy stronger, more direct, external political support than we do in the budget-making process. We should consider how best to build external support for our work and more effective representation of our interests in the budget-making process.

We recognize the constraints, professional and legal, which pertain to "exertion of influence" in the budget-making process. We do not advocate politicization of the profession. But, indirectly and properly, we can be more active in supporting the funding of agricultural economics work. For example, we might interact more extensively with IR-6, the SAES venture to support and coordinate SAES/SEA budgets for agricultural research. Perhaps we should seek more active involvement in the Joint Council on Food and Agriculture Sciences and its related bodies including the National Research and Extension Coordinating Committees and the regional councils and committees. Other institutions in which social science research and extension needs and priorities might be injected more effectively include the regional and national associations of land grant experiment station and extension service directors. Support from various interest groups might be explored.

Currently, funding of agricultural economics through the P.L. 89-106 Special Grants program is limited to one project—NC-117. Under management of CSRS, P.L. 89-106 authorizes "earmarked" funding of mission-oriented research in several disciplines. We believe that, in collaboration with CSRS, we should explore further this source of funds to support mission-oriented agricultural economics research. Further, we suggest that ERS and the land grant universities explore funding of joint projects through ERS appropriation requests.

Effective joint planning and leadership are required for any of these approaches to succeed. AAEA, the regional professional societies, regional committees, informal research groups, as well as ERS and CSRS are potential sources of such leadership.

At the state level an important source of new funding is from business, industry, and commodity or special interest groups. Often, small marginal increments from these sources will permit initiation or conduct of research or extension projects which might not otherwise be undertaken or fully completed. However, it is essential that management and publication control of research or extension projects funded by the private sector or, for that matter, funded by public agencies with action programs or special mandates, be retained by the research or extension agency. T. W. Schultz has spoken succinctly of the issue in a recent paper:

> The core of my argument is that one of the primary functions of academic economists is to question society's institutions. Economists are all too complacent about their freedom of inquiry. They are not sufficiently vigilant in safeguarding their function as educators. . . . The distortions of economic research will not fade away by accommodating patrons of research funds.

Develop Fewer, Larger Research Projects with a Regional or National Orientation

One of the important needs of the 1980s is to develop new mechanisms to allow extension specialists and research workers to make more effective use of their skills and knowledge across state and county lines with appropriate funding transfers which recognize these contributions. This is a longer-term problem with no simple solutions. Castle, in his impressive Kellogg Foundation Lecture to the National Association of State Universities and Land Grant Colleges, speaks clearly about this issue. The need to build credibility, make use of our specialized knowledge and comparative advantage within universities and disciplines, and reduce state and federal conflicts was emphasized. But we cannot simply wait for administrators to find ways to build bridges to allow greater specialization and reduce overlaps in research and extension. We should ourselves take the initiative. We have several suggestions.

Although performance of regional research projects has been uneven, we should continue to experiment with these devices. An objective should be to build a regional system for research and extension without the formal structure and bureaucratic processes which have encumbered many regional projects. The NC-117 model, with a permanent core staff, full-time executive director, and funding from the SAES, USDA, "off-the-top" regional

funds, and 89-106 Special Grants funds, has been highly successful in providing continuity of effort and coordination among participating institutions. Planning and commitments by the participating institutions are on a rolling three-year cycle—long enough to permit conduct of research but short enough to avoid permanent institutionalization of the project. That model might be adapted to research on other major problems.

A related, still-evolving mechanism to improve coordination and additivity in research is that of the International Trade Research Consortium, involving about ten U.S. and Canadian universities and the USDA (ERS and FAS) and jointly funded by those institutions. The Consortium evolved as an informal vehicle to bring together researchers having a major interest in and commitment to international trade research. Several workshops have been conducted and a research agenda has been established with the intention of seeking funding from government, nonprofit foundations, regional, and university sources. Without the formal structure of a regional project, but with a small core staff to provide continuity and assist in coordination of effort, this model of a successful working group might be adapted to other situations as a means of seeking major funding when project proposals are reviewed competitively.

A substantial amount of our resources is invested in development of quantitative economic models. Current requirements for development and maintenance of complex economic models are, in some cases, well beyond the technical and financial capabilities of any single agricultural economics research institution. We need to explore new institutional arrangements not only among U.S. institutions but with international research institutions as well.

Initiatives and multi-institutional innovations such as these usually turn on the leadership of a few individuals. We should do more to encourage such innovations. The AAEA is a logical forum in which to explore these and other types of institutional innovations through workshops, symposia, "commissioned" papers, and other approaches.

Participate Actively in Developing Research and Extension Proposals with Scientists in Other Disciplines

There is need for a small, but important, fraction of agricultural economists to commit themselves to take the initiative back at the project proposal stage to provide integration of economics and other disciplines. This will require specialization where an individual or a small team puts in perhaps 50% to full time on projects that span three to five years. The need for such leadership and commitment cuts across all aspects of the discipline: production, marketing, natural resources, and policy. In cases where such leadership originates in agricultural economics, more than token funding is likely to follow. Integration in the form of 10% of a scientific man-year annually is likely to lead to tokenism, with little impact on the project.

If public funding for research and extension is increasingly targeted to special problems as perceived by Congress and state legislatures, then agricultural economists must take leadership in developing proposals to solve these problems and help to define special projects for study. This will require specialization and a commitment to learn more about applied biology and engineering. It will be a mandate for a small percentage of all agricultural economists to be integrators with both fellow economists and those working directly with scientists from other disciplines.

In the near term at least, funding prospects appear brighter for the physical and biological sciences than for economics. On a purely strategic basis for future funding as well as for the reasons cited previously, we should consider seriously means of aligning ourselves more closely with those sciences. AAEA could encourage interdisciplinary work by regularly including a forum in its meetings for reporting the results of such work and extending its liaison representation to other professional societies. Some special recognition of published research in this area might provide further stimulus.

Concluding Comments

Comparatively speaking, we fared reasonably well in the funding of our work in the 1970s. But the 1980s pose new challenges and opportunities for us—prospective growth in demand for services and scarce, possibly scarcer, real resources.

To meet those challenges and opportunities requires that we be prepared to innovate institutionally; that we seek new approaches to conducting our work within the discipline and with other disciplines; that we set forth some

central directions and priorities to enhance our image and credibility with potential funding sources, old and new; that we attempt seriously to plan and, yes, even coordinate, our work in a manner to enhance our collective productivity and efficiency.

Passive observation of the changing environment of agricultural economics work will not improve our productivity or improve decisions in the allocation of scarce resources. But neither will short-run actions of expediency! What seems to us to be required is that we begin to view our individual services as collective services, not just for disciplinary purposes, but in the interests of agriculture, rural America, and the public at large. So viewed, collective action in the development of appropriate funding strategies seems appropriate.

The key to our suggestions is, of course, leadership—effective, forward-looking leadership—at numerous junctures in the profession. AAEA is one such juncture. It is in that vein that we have made our case and our recommendations.

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Funding for Agricultural Economics: Discussion

Joseph Havlicek, Jr.

Farrell and Stanton are to be complimented on an excellent paper dealing with (*a*) funding patterns and changes in support for research in agricultural economics and nonagricultural economics areas during the 1970s, (*b*) factors influencing the demand for services of agricultural economists and the capacity to service that demand, and (*c*) some strategies for funding agricultural economics research and for better utilizing resources currently available for agricultural economics research. I have no quarrel with any parts of their paper, and the focus of my discussion is on shedding additional light on some of their major points.

The analysis of funding patterns of agricultural economics and nonagricultural economics research by Farrell and Stanton is based on data obtained from a survey of heads of departments of agricultural economics and unpublished CRIS data on funding of agricultural economics research. To complement their analyses, I have analyzed the patterns in funding of agricultural economics research from 1970–79, as exhibited by the expenditures in twenty-three research problem areas (RPAs) which encompass agricultural economics research. The twenty-three RPAs analyzed were 108, 114, 316, 503, 506, 507, 508, 509, 510, 601, 602, 603, 604, 703, 801, 802, 803, 804, 807, 808, 902, 907, and 908. The data were obtained from the Inventory of Agricultural Research, volume 2, tables 2, 3, and 4, FY 1970–79. Some of the RPAs encompass other than agricultural economics research, but the total funds allocated to the RPA were used because there is no basis for separating out the funds allocated to agricultural economics research. The funds allocated to agricultural economics research covered by the RPAs include allocations to departments and research units other than departments of agricultural economics and agricultural economic units in the USDA. Also, the constant dollars were obtained by using the implicit deflator for government purchases of goods and services, which is a different deflator than the one used by Farrell and Stanton.

Farrell and Stanton found that the proportion of all agricultural research funds allocated to agricultural economics research was about 6% in the first half of the 1970s and a little more than 7% in the last half of the 1970s. Based on the data for twenty-three RPAs, the comparable proportion for the same time period ranged from 6% to 7% in the State Agricultural Experiment Stations (SAES) but from 9% to 13% in the USDA. Also, on a regional basis the South and the West had the lowest figures, 5% to 6% and 4% to 5%, respectively. In the North Central Region 7% to 9% and in the Northeast 7% to 10% of all agricultural research funds were allocated to agricultural economics research. None of these percentages exhibited any apparent trend during the 1970s, and thus agricultural economics research does not seem to be faring any better relative to other agricultural research.

In terms of changes in constant dollars, Farrell and Stanton found that funds allocated to agricultural economics research increased about 45% from 1970 to 1979, while constant dollars allocated to other agricultural research increased about 27%. The percentages based on the twenty-three RPAs are somewhat lower. In the SAES, the constant dollars allocated to agricultural economics research increased 42% from 1970 to 1979, and constant dollars allocated to other agricultural research increased 28%. The comparable percentages in the USDA were a 32% increase in constant dollars for agricultural economics research and only an 8% increase for other agricultural research. But some striking differences exist among the four major regions of the United States, with the South exhibiting an 85% increase in constant dollars allocated to agricultural economics research from 1970 to 1979

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and a 53% increase in constant dollars allocated to other agricultural research. In the Northeast, the constant dollars allocated to agricultural economics research increased about 41%, while the constant dollars allocated to other agricultural research declined 3%. In the West, constant dollars for agricultural economics research increased 45% and constant dollar funds for other agricultural research increased 28%. The North Central Region exhibited only a 12% increase in constant dollar funds for agricultural economics research and a 20% increase in constant dollars for other agricultural research.

The number of scientist years (SY) and funding per scientist year are other measures which provide some information about how agricultural economics research compares with other agricultural research. The 1979 data on scientist years is preliminary and questionable, so the analysis of the data for the twenty-three RPAs was performed for the 1970–78 period rather than the 1970–79 period. In the SAES the number of scientist years devoted to agricultural economics research increased 22%, and the number allocated to other agricultural research increased 12%. In the USDA the increases in scientist years are considerably less, with agricultural economics research exhibiting a 3% increase and other agricultural research showing only a 1% increase. In the SAES the constant dollars allocated per scientist year in agricultural economics research increased 7% from 1970 to 1978 and increased 18% in other agricultural research. In the USDA the constant dollars per scientist year increased 45% in agricultural economics research and 15% in other agricultural research. Hence, there have been greater increases in SYs in the SAES, but the constant dollar funds per SY have increased considerably more in the USDA than in the SAES.

One cannot help but comment on the fact that in the survey conducted by Farrell and Stanton not one department chairman or administrator gave rural development a high-priority rating. It is doubtful that this result implies that those responding do not feel that important economic problems exist in the rural development area. Rural development research has been difficult to assess, and the usefulness of some past research in this area has been questionable. One of the difficulties with assessing rural development research is that the output of the research is difficult even to identify, and little headway has been made in measuring it.

Finally, there seem to be some severe difficulties with the general public, and these difficulties are likely to get worse. Even though the figures discussed by Farrell and Stanton and myself suggest that agricultural economics research has fared no worse than other agricultural research, the increases are not exactly spectacular, given that they encompass ten funding years. The increases are indeed modest. Science and research have lost credibility with the general public as well as the public's support. It may be a characteristic of the time that it is bad to be an agricultural scientist, even worse to be a social scientist, and worst of all to be a social scientist in agriculture. Part of the difficulties with the general public may be due to the inadequate job we have done in informing the general public about what researchers do and the benefits of their activities. Even in cases where attempts have been made to communicate the benefits of research activities, the focus has been on producers and legislators and not on consumers, who are the ultimate beneficiaries of agricultural research. However, the problem may be more serious than communication. Agricultural economists may not be dealing with the important and relevant economic and policy issues of the general public. This, of course, is more difficult to deal with than just improvement of communication. But both of these difficulties with the general public offer challenges and opportunities for the 1980s.

Funding for Agricultural Economics: Discussion

W. D. Toussaint

I would like to commend Stanton and Farrell for the work they did in compiling the data for their paper and for supplying us with their analysis and recommendations. I will comment on several points relative to both data and recommendations.

Their data seem to show an increasing share of the public sector research dollar going to agricultural economics research in the last decade. This may be true. It may be, however, a function of the CRIS system and how research projects are coded. They retrieved their data on Field of Science 2630 (economics). I found earlier that a very high proportion of the 2630 research in some southern states is in other departments (Toussaint, p. 24). We would have to know what the trend has been in reporting 2630 in other departments, to have a better feel for this. Further, I found (p. 25) that the share of state agricultural experiment station funds expended in agricultural economics departments generally fell in the southern states from 1967–68 to 1977–78, which seems a little at odds with the findings of Farrell and Stanton. Funding for extension activities in these same states also seemed to decline slightly.

Farrell and Stanton show that more department heads indicated an increase than indicated a decrease in agricultural economics funding as a proportion of college budgets. I suspect this is due primarily to the teaching component. If the lag in reallocating teaching funds were not so long, I suspect that we would have an even larger share of university budgets today. This agrees with the authors' point that research may have subsidized teaching during this period of rapidly increasing enrollments. Throughout the nation we have had greatly increased enrollments in business and economics. As a consequence, teaching loads have become much larger in these areas.

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Why might our share of research funding have dropped, if it has? I believe that agricultural economics research has declined in value in the eyes of experiment station directors in recent years. Real funding for research has decreased, and, as budgets are squeezed, directors look for projects with visibility and high, immediate payoff. We do not always rate well on these scores. As experiment stations rely more on nonpublic funding sources, they must have research that has high payoff to their commodity groups. Ruttan (p. 12) says:

> . . . both consumers and producers tend to support those agricultural research activities with which they have the most direct contact. The relatively sophisticated arguments based on relative shifts in demand and supply functions and on changes in producers' and consumers' surplus have apparently been difficult to translate into a language that generates political support from organized producers or consumers.

Rural development research has hurt us in many eyes, and this is not all our fault. Remember that the money was almost forced upon us and, in many cases, only replaced funds for other projects. Many of us were not ready for this kind of research; we did not always have all the skills. As a consequence, much of our work was not particularly good. Other research was not easy to evaluate.

Farrell and Stanton ask why we should have to get new funding by attaching riders to physical science requests. It may be a little difficult for us to swallow, but this may continue to be a good strategy. Riding with physical science requests and participation in interdisciplinary research may be two of our best strategies for gaining visibility and funding.

I must admit to being less than hopeful about gains to be achieved by our profession as a group, spelling out and advertising our needs and our contributions. Previous attempts to do this often have ended looking like the usual report put together by a committee. For example, *Animal Agriculture: Research to*

Strategies for Dealing with World Hunger
(D. Woods Thomas, Purdue University, Presiding)

Strategies for Dealing with World Hunger: Post-World War II Policies

Wayne D. Rasmussen and Jane M. Porter

Farmers, farm politicians, and agricultural economists have something in common. Their products, whether food, laws, or theories, are dependent upon the weather. This is obvious in the case of farmers. Their product depends upon many things, including the state of the arts in agriculture in a particular region or nation, the availability of credit, the costs of energy and fertilizer, and so on, yet the overriding variable, with only limited exceptions, is weather. If the monsoons are favorable in India, the frost holds off in the Soviet Union, and timely rainfall comes to Argentina, Australia, Canada, and the United States, there is a world surplus of grain. Conversely, if weather conditions are unfavorable in these areas, the world faces shortages.

If there are surpluses, politicians face the problem of establishing programs that will assure farmers reasonable incomes, reduce production, remove surpluses from the market and dispose of them, and bring about the retention of the politicians in office, all at little cost to the taxpayer. If there are shortages, the problems are still complex, with questions of export embargoes, high consumer prices, the maintenance of farm income, the stimulation of increased production that will ease shortages and not lead to surpluses, and the retention of the politicians in office, all at little cost to the taxpayer.

The relationships between the weather and the agricultural economists is not so clear unless we accept and keep in mind the proposition that weather is the most important of all the variables in determining whether we have surpluses or shortages, or, indeed, whether we reach that golden mean where production equals effective demand. Thus, over the past thirty-five years since World War II, the dominant economic theory at any given moment has been, when surpluses were at hand, they threatened to drag the economy down to disaster; or, if there were shortages, the world was threatened with starvation and wars over food supplies. Oddly enough, weather conditions, with their resulting surpluses or shortages, led some economists to make rather short and fast turnabouts. For the most part, though, it appears that economists belonging to two different schools of thought have taken turns explaining their theories and making their forecasts as world weather has changed.

Because there is little we can do to bring about major changes in the weather, at least with present technologies, we will accept it as given, so far as this paper is concerned. Our purpose will be, then, to look at the relationships between agricultural policies and programs as they relate to world food supply and to look at economic theories and forecasts because they have an effect on policies and programs. The programs and policies of many nations and of international organizations affect the world food supply, but our paper is limited to those of the United States, with some attention to the relationships of the United States to other nations and to international organizations.

World War II ended with American farmers reaching the highest levels of food production ever in 1945 and 1946, yet world shortages threatened many people with starvation. Vocal American consumers, because of high incomes and rationing and shortages during the war, were calling for the removal of all

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restrictions on consumption. Producers felt that price controls had limited their possible profits and also were urging the end of controls (Wilcox).

The federal government had been discussing postwar relief in Europe and other parts of the world almost from the time of Pearl Harbor. By the fall of 1943, various proposals and discussions had led to an agreement to establish the United Nations Relief and Rehabilitation Administration. The agreement was signed on 9 November 1943, by the representatives of forty-four nations. The Department of Agriculture played an important part in establishing and staffing UNRRA.

UNRRA was to be a temporary organization that would end with the completion of its mission. Even before it was established, a permanent international organization to deal with food and agricultural problems was being discussed, with an international conference held at Hot Springs, Virginia, in May and June of 1943. In July 1945, the Food and Agriculture Organization of the United Nations came into being. The Department of Agriculture had been the continuing force behind the establishment of FAO and contributed heavily to its staffing.

By the time the postwar food crisis hit the world, there were international organizations and sheaves of plans in the Department of Agriculture for dealing with it. However, there was not enough food to go around. The tremendous grain reserves had been turned into meat, dairy, and poultry products to feed our armed forces, allies, and civilians. During the last months of the war, some policy makers had determined to leave a bare pantry, fearing that surpluses would soon return, as they had following World War I. The policy makers of various agencies and allied countries distrusted one another, each thinking that the other was hoarding large stockpiles of food. However, the stockpiles proved to be imaginary. The crisis was so severe that President Truman announced a series of emergency measures and appointed a Famine Emergency Committee and a National Famine Emergency Council to provide leadership and obtain public support for the effort. Later a Citizens grain. From 1945 to 1948, the United States supplied more food to the hungry abroad than any other nation has ever done before or since. The question still remains whether or not our efforts were adequate. As might be expected, evaluations about what should have been done and what was done vary. One well-known economist, Theodore W. Schultz, said in 1946: "The United States has on several major counts—seriously, in my judgment—mismanaged its food supplies. . . . in the United States the average person's consumption has jumped to the unprecedentedly high level of thirty-three hundred calories per day. . . . we should return to our wartime levels of food consumption, in order to stand by the European and Oriental peoples during this world-wide food crisis" (Moore, Schultz, Tolley, pp. 22–23).

The postwar planning effort in the U.S. Department of Agriculture (USDA) was led mainly by some of the Department's outstanding economists, including Howard Tolley, Leslie Wheeler, Roy Kimmel, Raymond C. Smith, Louis Bean, and Mordecai Ezekiel.

Soon after the outbreak of the war in Europe and long before Pearl Harbor, President Roosevelt had ordered each cabinet officer to produce a set of postwar projects. One objective of this exercise was to be prepared for a postwar economic slump. The economists in the USDA saw this as the opportunity to make some badly needed long-term adjustments in the American agricultural plant. Plans were to be prepared for each major region of the country. The principal concerns were (*a*) an adequate income and level of living for farm families; (*b*) care of the soil, with consideration for the differences in soils and climates to insure a permanently productive agriculture; and (*c*) production of those commodities demanded by the market with abundance but no large surpluses.

The postwar plans of the economists in the USDA, in retrospect, seem sound to us. Many of their objectives have been achieved, with or without planning. But when the content of these plans reached the ears of the public, the wrath of certain influential politicians descended on the department. The responsible

passed the Foreign Assistance Act, the authority for the Marshall Plan to revive Western Europe. Substantial shipments of food were made under the plan. Amid all of the crisis activities a few economists began taking a longer look into the future. Pearson and Harper, writing in the closing months of the war, held that food shortages were caused by demand for higher quality food and a worldwide shortage of arable land. They offered no hope of a rapid worldwide increase in food availability and postulated that if a projected rapid increase in population materialized, diets would have to be downgraded if famine was to be avoided in some parts of the world. Albert Viton, chairman of the International Emergency Food Council, told the Farm Economics Association in 1947 that a new economic philosophy had emerged in the postwar period. This philosophy of "full employment" would lead to rapid economic growth, increased demand for higher-quality food, a period of relative prosperity for agriculture and rapidly increasing agricultural output in both the developed and less developed areas. He cautioned, however, that there would be regional maladjustments and that the United States might see the return of surpluses by 1949 or 1950 (Pearson and Harper).

The first worldwide census effort, made under the auspices of the United Nations in 1950, showed that a population explosion was in progress. The world, by this time sorely divided by the cold war, faced an indefinite period of food imbalances and insecurity. The traditional bread basket of Europe was behind the iron curtain. The rice bowl of southeast Asia was torn by fratricidal warfare. A new group of economists at the USDA began to see long-term opportunities for American agriculture in foreign markets.

The message went out to American farmers: "Expect to fill a fifth plate at the dinner table." That is, agricultural exports were expected to take about one-fifth of our production. Farmers could maintain and even expand production without fear of price-depressing surpluses.

The euphoria was short-lived. With the end of the Marshall Plan and the Korean War, surpluses returned in the United States. Although there had been proposals for the establishment of international buffer stocks and reserves of food under consideration since 1937 and the subject had generated a good deal of heat at the Hot Springs Conference, the economists, here and abroad, could only agree to disagree. Even the International Wheat Agreement ratified in 1949 made no provision for food reserves.

The Agricultural Act of 1949 provided the first authority for donating surplus agricultural commodities abroad through United States voluntary relief organizations. A significant step in technical assistance also came in 1949 when President Harry Truman, as Point 4 of his foreign policy, stated that we must make our scientific and industrial advances available to underdeveloped areas. Special legislation provided for food donations to help the Greeks and Turks in their fight to repel communist take-over attempts in 1952 and to relieve famine in Pakistan in 1953 (Matusow). In 1953 the legislative hoppers were filled with proposals to get rid of agricultural surpluses by shipping them out of the country by one means or another. The prospect of large-scale export dumping by the United States alarmed the other wheat exporting countries and some major developed importing countries. The 1953 session of the FAO Conference, after considerable discussion, directed its Committee on Commodity Problems to study the means and principles of international disposal of surplus agricultural commodities. The Committee met in Washington during February and March of 1954. It produced a set of recommended principles to be followed in the disposal of agricultural surpluses. From the language used in this document and the language which became U.S. law in the Agricultural Trade Development and Assistance Act, better known as P.L. 480, it is apparent that there was very close communication between the Committee on Commodity Problems and those who drafted P.L. 480. Mordecai Ezekiel reportedly drafted the "Principles" recommended by FAO (United Nations 1954).

In spite of the language similarities, however, the Agricultural Trade Development and Assistance Act did not result from FAO proposals. There were a number of surplus-disposal bills introduced in 1953, as noted previously, and there were a number of committees studying them. In a maze of bureaucratic wrangling, the interdepartmental committee on the surplus, established by President Dwight Eisenhower and chaired by Undersecretary of Agriculture True D. Morse, finally agreed on an administration bill. It was a compromise between the proposals of the American Farm Bureau Federation and the desires

of several federal agencies to control the new program. The bill moved quickly through the Congress and was approved by the president on 10 July 1954 (Peterson, pp. 36–41). The law has remained a cornerstone of American programs relating to world hunger.

Public Law 480, as enacted in 1954, had four titles: Title I provided for sales of surplus agricultural commodities for foreign currencies which could not be converted into U.S. dollars. The disposal of these currencies was to be arranged through agreement between the receiving country and the U.S. State Department, but a certain percentage was to be reserved for U.S. uses such as financing our embassies. Title II provided for donations of surplus commodities for disaster relief through U.S. voluntary organizations of friendly governments. Some limited donations could be made for economic development. Title III provided for the barter of surplus agricultural commodities for strategic and critical materials to be added to U.S. stockpiles of these materials. Title IV provided for long-term credit to finance dollar sales of agricultural commodities. Titles I and II cover the P.L. 480 functions that will be discussed in this paper.

Mordecai Ezekiel and Rodan Rosenstein were sent to India by the FAO to monitor the first use of surplus food. This landmark research provided the detailed economic rationale for the use of surpluses to help finance economic development. The study concluded that surpluses to be used for development should be tied to an equal amount of other resources and committed to designated projects. When surpluses are used to put unemployed men to work and they produce something that adds to the capital goods of the country, development is taking place (Ezekiel; Iowa 1962, pp. 278–301; UNFAO 1955).

Although forty-eight countries accepted the principles set forth by the FAO on the disposal of agricultural surpluses, and these were reaffirmed when the Wheat Utilization Committee was established in 1959, they were more frequently honored in the breach than in the observance at least up until 1965.

The terms of surplus agreements under P.L. 480 in the late 1950s and early 1960s put more emphasis on protecting and maintaining "usual" commercial imports than on uses for development or preventing the concessional sales and grants from acting as disincentives to farmers in the recipient country. The Subcommittee on Surplus Disposal of the Committee on Commodity Problems of the FAO continued to monitor surplus disposal. Studies in Japan and Pakistan showed that the program had worked along recommended lines in Japan, but that in Pakistan and some other countries it had only supported increased consumption. Cheap food policies in many Latin American and Asian countries tended to stifle domestic agricultural production. Sudden cut-offs of commodities after countries had become dependent on them carried serious threats to vulnerable populations. In 1959, for example, the cut-off of supplies of dry skim milk was damaging to child-feeding programs in many countries (Davis, Shefrin, Iowa 1962).

The FAO objectives of food for development proved difficult to implement. The agencies with capital to disburse, such as the World Bank and the U.S. International Cooperation Administration, favored large capital-intensive, show-piece projects. Food-for-work inputs to such projects were a nuisance. Small labor-intensive projects cost too much to administer. Furthermore, the voluntary agencies who disbursed a large part of the food-aid grants were oriented toward charitable, disaster relief types of operations and protested against the requirements that their deprived clientele be forced to work for food donated by the American people. Nevertheless, a few highly successful food-for-work projects were implemented during the 1950s. For example, Elmer Starch conceived and carried out a pioneering program of reforestation and small-scale irrigation in Tunisia.

During the late 1950s much of the surplus food sold for local currencies went to technically advanced but food-deficit countries: Japan, Israel, Taiwan, and Korea. Each was densely populated, with limited tillable land. Each of these countries concurrently invested in developing its own agriculture, perhaps not with the objective of becoming self-sufficient in food, but of developing a highly productive specialized agriculture. Each graduated from food aid dependency during the 1960s and has become a sometime-competitor, sometime-customer for U.S. agriculture. Surplus disposal had justified some of the original theoretical expectations but had opened up a whole series of new problems (DeBlois).

India was an example of food aid results at the other extreme. By 1960 the accumulation of blocked currencies resulting from P.L. 480 sales was so large that it was threatening the

financial structures of the country (Purvis). Surpluses were being produced in the exporting countries, particularly the United States, faster than they could be channeled into consumption, regardless of the mode of payment or nonpayment. The original AAA of the U.S. program had been designed to control production, but through political and economic pressures over the years it had put a premium on efficiency resulting in increasing yields and increased production. World prices of commodities were in a continuous downward trend from the early 1950s. This was the principal item on the agenda for the meeting of the Economic and Social Council in the summer of 1959 (United Nations 1959). Obviously the large volume of U.S. exports, both commercial and concessional, had influenced the trend of world prices. Thus, our exports had become a disincentive to the expansion of production. At any rate, it was necessary to negotiate in 1959 a P.L. 480 agreement of record-breaking magnitude with India to fill her food grains deficit during the ensuing four years. The morocco-bound volumes of a landmark study entitled *India's Food Crisis and Steps to Meet It* were left to molder on the shelves of the library of the Ministry of Agriculture (Ford Foundation). This study had been funded by the Ford Foundation and led to its rural development program in India which, in the short run, did little to increase food availability. By 1965, when the monsoon failed, India was already a basket case.

But by 1965 the economists had provided the politicians with a whole new basket full of economic theories and statistical data. Galbraith, having published *American Capitalism; the Concept of Countervailing Power* (1956), *The Affluent Society* (1958), and *Economic Development in Perspective* (1962) and having also served as U.S. ambassador to India 1961–63, was advising and criticizing the administration in Washington from his dais at Harvard. Walter W. Rostow, having produced *The Stages of Economic Growth, a Non-Communist Manifesto*, was firmly entrenched in the inner policy making councils of the State Department. Gunnar Myrdal assumed the mantle of Thor with publications like *Rich Lands and Poor*, *The Road to World Prosperity*, and *Challenge to Affluence*, and was writing the *Asian Drama, an Inquiry into the Poverty of Nations* in 1968.

The period 1959–65 witnessed an upsurge in publications on economic development, agricultural development, and food and population problems. The views of Galbraith and Rostow dominated a study on foreign aid policies produced by the Maxwell Graduate School of Citizenship and Public Affairs for the Senate Foreign Relations Committee in 1959 (U.S. Congress, Senate, Foreign Relations Comm.). Thus study suggested that food surpluses be committed over a period of years to enable countries to use their limited financial resources to push industrial development. It stated that many of the densely populated less developed countries (LDCs) could never hope that agriculture could supply an adequate level of living for their populations. Its policy repercussions are evident in the aforementioned P.L. 480 agreement with India and in India's second five-year plan which stressed industrial development.

Bruce F. Johnston and John W. Mellor began the counterattack with "The Nature of Agriculture's Contribution to Economic Development" published by the Stanford Food Research Institute in November 1960. A year later in the *American Economic Review*, they published "The Role of Agriculture in Economic Development." Johnson and Mellor postulated three phases in agricultural development:

Phase I: Providing the preconditions for agricultural development.

Phase II: The use of low-capital, labor-intensive technology results in increasing yields per acre and overall production.

Phase III: Reinvestment of profits in the agricultural sector leads to more capital-intensive technologies, reduced labor inputs and rapidly rising productivity.

The authors said that due to the availability of cheap land and the scarcity of labor, this development path was not followed by the United States. Japan and Taiwan were cited as good modern examples.

A session at the 1960 annual meeting of the Farm Economic Association featured a paper by Theodore W. Schultz on the "Value of U.S. Farm Surpluses to Underdeveloped Countries." Max Myers, at another session, said that public support for the use of agricultural surpluses to meet the food needs of food-deficit countries was a dynamic movement in both the producing countries and the deficit countries. This was evident in public support for "Food for Peace" and FAO's "Freedom from Hunger" campaign launched in 1960. Don Paarlberg had left the Depart-

ment of Agriculture late in 1958 to head a Food for Peace office in the White House.

A new thrust of research on world food problems began early in 1961 in the USDA. The initial product, entitled *The World Food Deficit, A First Approximation,* was published in March 1961. This was followed in October 1961 by *The World Food Budget 1962 and 1966.* These studies led to a contract (called a PASA) with the Agency for International Development for the Economic Research Service to carry out a study of agricultural development in twenty-six developing nations (USDA 1965). A study group headed by James P. Cavin was established by Willard Cochrane in the Economic Research Group in 1961. Its widely circulated report, issued in March 1963, stressed the importance of agriculture to development.

Meanwhile, a young economist in the USDA was writing two monographs, *Man, Land and Food, Looking Ahead at World Food Needs* followed by *Increasing World Food Output: Problems and Prospects.* Lester R. Brown, the author, acknowledges in the preface to the latter volume that he had attempted to apply Rostow's concepts of economic growth to the agricultural sector, substituting yield per acre for income per person in applying the takeoff concept. Politically, it was a coup, as Rostow reciprocated by acknowledging the role of agriculture in economic growth. Secretary of Agriculture Orville Freeman's objective of reestablishing the role of agriculture, and particularly of the USDA in the foreign aid program was advanced. Funding from AID for continuing USDA research on agricultural development was assured and the participation of action agencies such as the Forest Service, the Soil Conservation Service, the Rural Electrification Administration, the Agriculture Stabilization and Conservation Service, and the Agricultural Research Service in foreign agricultural development projects was gradually increased. A new agency, the International Agricultural Development Service, was established to coordinate USDA participation.

Research on agricultural development was also expanding in the land grant colleges and other institutions. A notable conference, which brought together professionals from many disciplines to discuss the role of food and agriculture, was held at Iowa State University in February 1962 (Iowa 1962). A World Food Congress was held in Washington, D.C., 14–18 June 1963. It was jointly sponsored by the FAO Freedom from Hunger Campaign, the U.S. Agency for International Development and the USDA. The list of participants read like an international Who's Who. Arnold Toynbee and Orville L. Freeman expressed opposing views on the future prospects of the world's ability to feed itself. Freeman, the optimist, said that the export of U.S. technology would produce a worldwide explosion in yields (Toynbee, Freeman 1963).

The imaginative use of U.S. surplus stocks of grains to "buy time" while development programs increased yields in food-deficit countries was also advocated by the Freeman administration. When the food crisis developed in India in 1965–67, it was thoroughly dramatized both in the United States and the rest of the world as a foretaste of things to come if the imbalances between food supplies and population growth were not corrected. A galaxy of specialists from many disciplines was sent by the USDA to India to help revamp her agricultural development program. Freeman took advantage of the desperate need for U.S. grains to prod the Indian government into implementing the recommendations of USDA specialists. Under the pressure of the Indian food crisis, amendments to Public Law 480 were pushed through the U.S. Congress. These amendments redirected the program from surplus disposal to use as a tool in promoting agricultural development in food-deficit countries (Freeman 1968).

In his "Message on Food for Freedom," 10 February 1966, President Johnson directed his Science Advisory Committee to study the world food problem and recommend ways and means of increasing the world's food supply. The panel appointed by the committee studied the problem for a year with the full cooperation of all of the applicable disciplines and institutions. The report, published in May 1967, concluded that hunger and malnutrition were not primary diseases of the last half of the twentieth century but were symptoms of a deeper malady, lagging economic development on three continents where nearly two-thirds of the world's people live (President's Science Advisory Committee). Abel and Rojko, in the USDA, asserted that over the long pull, U.S. food production would be able to meet the market demand for food and that this should have primacy in USDA policy considerations. New, high-yielding varieties of wheat and rice spread rapidly in the food-

deficit regions, normal weather returned, and surpluses began to accumulate again in the United States. Public concern over the food crisis abated (Dalrymple).

The commitment of the Johnson-Freeman administration to agricultural development as the means of solving the world food problem continued for the duration of their incumbency. In 1968 Freeman urged major attention to international food development in his book *World Without Hunger*, but by this time the country was immersed in the Vietnam War. Conflict over the Vietnam War seemed to turn American public opinion inward. Foreign aid became equated in the minds of the public and the politicians with U.S. dollar imperialism or worse things. As long as the Vietnam War continued, the U.S. Congress continued to be hostile to foreign aid. Between 1968 and 1972 the question of the future of foreign aid was studied by a number of prestigious groups, including the American Assembly of Columbia University; a task force of the National Association of State Universities and Land Grant Colleges; the National Planning Association; The Committee for Economic Development; the World Bank; joint report by Clifford M. Hardin, Secretary of Agriculture, and John A. Hannah, Administrator of AID to President Nixon (Hannah and Hardin); and a presidential Task Force on International Development (known as the Peterson Report). The recommendations of these study groups were diverse, but there was a common thread of emphasis on agricultural development. The United States should increase its foreign aid expenditures; more emphasis should be placed on agriculture and population programs; technical assistance and development lending should be funded on a multiyear basis; debt burdens of the LDCs should be eased; and trade concessions should be made for them. Despite this support, aid authorizations and appropriations were regularly shaved to the bone and even then were barely passed by the Congress.

The early 1970s saw American food policy influenced by devaluations of the dollar, the "great Russian grain robbery," "embargoes" on wheat and soybeans, the unprecedented increases in agricultural and food prices, the organization of OPEC, and the escalation of petroleum prices (Breimyer, pp. 3–5). Close on the heels of these developments, drought in the Sahael brought on a new food crisis. There arose an outcry that the United States had no food policy, domestic or foreign. Meanwhile, Secretary of Agriculture Earl L. Butz was saying that increased production would solve our problems and was urging farmers to plant "from fence row to fence row."

The U.S. Congress began to change its attitude toward foreign aid programs beginning in 1974. AID was directed to address its programs to meeting the basic human needs of the poorest countries. The dilemma in food is that those who do not have enough do not have the money to pay for it and those who produce more than they need cannot afford to give it away.

The dilemma was stressed at the meeting of the World Food Conference in Rome in 1974. A number of recommendations were made by the conference which may have had some effect upon national policies (U.S. Congress 1975). However, the recommendations would, for the most part, still be appropriate today. One result of the conference of great value to economic analysis was that it was the immediate impetus for the establishment of the International Food Policy Research Institute (IFPRI, pp. 3–5).

The World Hunger Commission promised a new assessment of current and future food problems when it began work in 1978. Yet, regardless of the findings and recommendations of the Commission, the United States probably will continue to be influenced by political realities, recommendations of agricultural economists, and the weather in making or changing its policies on world food supplies. We do know that total food production by developing countries rose steadily throughout the seventies but varied greatly by region (USDA 1980).

Secretary of Agriculture John R. Block has stated repeatedly that increasing farm exports is one of his major goals. He emphasizes commercial exports, but does not rule out shipments for disaster relief. There are problems associated with maintaining or increasing exports. The United States has become a residual supplier, which means that the prices farmers receive for exports may vary markedly from year to year. We may have surpluses or shortages from one year to the next, depending in large part upon weather conditions throughout the world. Maintaining high productivity for export may be reducing soil fertility and making the soil more subject to erosion. It has been charged that meeting world demand increases consumer prices in the United States (Cochrane p. 274, O'Brien).

On the other hand, we may be moving into a

new state of equilibrium, as John Lee has suggested, with production and effective demand being in relative balance. But Don Paarlberg leaves us with a challenge: "Enough food? Yes, if we act wisely. If there is scarcity it will be because, with unwise policies, we have brought it upon ourselves."

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Reflections on the Presidential Commission on World Hunger

Walter P. Falcon

In September 1978, then President Jimmy Carter appointed a twenty-member Commission on World Hunger. The commission's mandate was to identify the basic causes of hunger at home and abroad, to assess programs and policies affecting hunger, and to recommend (and publicize) specific actions to create a coherent national policy. The group had bipartisan political support, and four of its members were from Congress.[1] Unlike previous commissions of food and agriculture, however, representation from economists and agricultural scientists was quite limited. Although this was both a strength and weakness of the commission, it had the unfortunate consequence of involving fewer professional groups than might have been desirable. In part, therefore, this essay is an after-the-fact (and slightly expurgated) report to agricultural economists on "what happened."

Because the entire commission *Report* is readily available, I will not summarize its findings, although a number of recommendations from the *Report* are highlighted.[2] The many changes (including the presidency) that have occurred since the commission reported formally in March 1980 suggest instead the need for a critical appraisal of the *Report* and for comments on possible next steps for the United States in the field of hunger alleviation.

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The helpful comments of Bruce Johnston, Scott Pearson, and Anne Peck are gratefully acknowledged. Variations on the themes of this essay were given previously at Macalester, Purdue, and Michigan State Universities.

[1] The commissioners included Sol Linowitz (chairman), Jean Mayer and Steven Muller (vice chairmen), Norman Borlaug, David Brooks, Harry Chapin, John Denver, Robert Dole, Walter Falcon, Orville Freeman, Benjamin Gilman, Patrick Leahy, Bess Myerson, Richard Nolan, Howard Schneider, Adele Simmons, Raymond Singletary, Jr., Eugene Stockwell, Clifton Wharton, Jr., and Thomas Wyman.

[2] The Presidential Commission on World Hunger no longer maintains an office; however, copies of the *Report* are for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. (Stock No. 041-002-00015-8, $6.00 per copy.)

Dimensions of the Hunger Problem

Perhaps the strongest aspect of the commission's *Report* is its description of global hunger. Unlike other documents, for example, the recent National Academy of Sciences study that emphasized production problems and technical solutions, the *Report* is much broader in its scope and outlook. Much of the *Report*'s extensive, and often moving, description of hunger can be captured in five words: Asia, children, calories, chronic, and poverty.

In setting forth the quantitative dimensions of hunger, the commission began implicitly from the framework suggested by Reutlinger and Selowsky. The incidence of hunger is estimated with this methodology from consumption-income relationships. To the extent that personal needs, average daily requirements, income distributions, or Engel coefficients are misspecified, the resulting conclusions on the number of hungry people are also affected. Using different assumptions, Eberstadt, for example, concludes that hunger affects perhaps only 100 million people, with the most severe problems concentrated in Africa. By contrast, however, the commission concluded that between 500 million and 1 billion people suffer from moderate to severe protein-calorie malnutrition (PCM). Large and disquieting as this range may be, it probably has little bearing on America's attitude or its capacity to help with solutions. Hence, there seems little need, at least in this essay, to fine-tune estimates, as further refinement would have little bearing on public policy.

Policy direction, however, does depend importantly on the five words mentioned previously. Of the approximately 800 million people thought to be suffering from moderate to severe undernutrition, about two-thirds are in Asia. Indeed, on a global basis, about 70% of all hunger is in nine countries, (India, Pakistan, Bangladesh, Indonesia, Philippines,

Kampuchea, Zaire, Ethiopia, and Brazil). Any domestic or international proposals aimed at ending world hunger must deal fundamentally with these nations. The difficult formal relationships between the United States and a number of these countries underscore immediately the political dimensions of the hunger problem and the limits to which the United States can now help with a solution—assuming that it wishes to do so.

Irrespective of the exact total of hunger-affected individuals, there are special groups within populations where PCM incidence is the highest. Weanling children from ages one to four present the most serious problem. Whereas cereal-based diets are largely adequate for adults, the relatively low density of these foods means that small children literally cannot eat enough of them to be nourished adequately. In addition, the interactions among undernutrition, poor water quality, and other public health components are especially critical among the young. These interactions are one reason, for example, infant mortality rates in Africa are more than six times the level of developed countries. As the *Report* correctly notes, unless infant mortality rates can be reduced, it is unlikely that birth rates can be brought down a significant degree.

Pregnant and lactating women are also given special attention. The extra strains of childbearing place these groups seriously at risk with respect to nutrition. In addition, a generational effect deserves specific mention. There is almost no existing scientific evidence to suggest physiological relationships between mental retardation and undernutrition. An exception to this statement is that undernourished mothers fail to carry fetuses to full term much more frequently, and among premature births, the incidence of mental and other handicaps is substantially higher. On the other hand, there are strong correlations among moderate or severe undernutrition in children, learning motivation, and behavioral patterns.

One important implication for economists of the "children and mothers" component of the problem concerns household allocations of food. Many analysts typically think of household consumption as the central unit of observation. Unfortunately—since the issue presents severe research and intervention difficulties—how food is allocated within families may be at the very core of the hunger program in many situations.

A third component of the hunger problem involves calories. Although this point is increasingly recognized, it also is true that for twenty years many in the nutrition profession had the world pointed in the wrong direction. Indeed, survey work by the commission indicates that many Americans still believe that protein is the most severely limiting nutritional element. Except in a few localized regions, however, the overwhelming PCM problem is simply getting enough calories. Widespread evidence suggests that groups with sufficient energy resources have typically also found ways to provide the necessary protein complement.

A fourth element in defining global hunger concerns its chronic dimension. Partly as a result of modern communications, the specters of war- or drought-induced famines are well known to most families in the United States. The coverage of events such as the Sahel drought, the Kampuchean and Somalian disasters, or the boat people from Viet Nam are almost daily occurrences on television. Horrible as these situations are, they simply are not the dominant hunger problem in terms of numbers. Clearly, the intensity of the PCM problem is worse in famine areas, but it is also true that famines occur much less frequently or severely than even fifty years ago. In addition, global support generally can be mobilized much more readily for disasters than for hunger of a chronic nature. It is easy enough for responsible persons to grasp the hunger complications caused by drought. It is almost impossible, however, for anyone to visualize one-sixth of the people on earth suffering from moderate to severe continuing undernutrition.

Of all the definitional components, however, the *Report* comes down most firmly on the issue of poverty. There may be isolated instances where people are undernourished because they are not making good use of local food resources in terms of either total quantity or composition. However, the overwhelming reason people are hungry is not because they are ignorant or uneducated but rather because they are poor.[3] The recognition that poverty, and not food production, is the major problem is an important step forward, especially for the agriculturalists (and others) who may believe the contrary. Yet the implications are sobering

[3] An exception to this statement involves infant-feeding practices, where educational efforts can sometimes make an important difference.

on two counts. First, a question is immediately raised as to whether those "who are poor, need not be hungry as well" (*Report*, p. 40). In the United States, largely through the Food Stamp Program, it has been possible to separate these two afflictions.[4] Given both the resource costs and the administrative problems encountered in America, however, can or should similar programs be replicated in low income nations? Second, if it is impossible to separate hunger from poverty, what can outsiders—even well-meaning ones—do to help attack the fundamental problems of income levels and distribution? This latter issue was at the base of many of the commission's deliberations. Given the wide range of political views represented on the commission and its staff, many of these sessions exhibited heat if not light.

Vigorous debate notwithstanding, the commission came eventually to a shared perception of the major causes of global hunger and also to some of the needed solutions that followed directly from problem definition. For example, it agreed that improvements in nutrition and infant mortality were a prior condition to solving population-growth problems and not vice versa. Similarly, it concluded that increased food production was a necessary, but not sufficient, condition for solving hunger. But in other areas, mainly associated with methods for alleviating poverty, the *Report* contains curious contradictions, both in the main text and in the numerous dissenting comments.

Hunger Alleviation within the World Food Economy of the 1980s

Of the numerous operational recommendations in the *Report,* issues surrounding trade, debt, and world food security occupy a prominent position. Some of the reasons for this focus are clear. The rise in oil prices had badly hurt a number of low income, food-importing countries that had been caught in a double balance-of-payments bind during the 1970s. Agricultural trade, including food aid, were also fields in which the United States was dominant. Somewhat ironically, however, the linkages among agricultural trade, poverty, and hunger are among the weakest analytically in the entire *Report,* and a generally inadequate case is made for linking hunger problems with other developments in the world food economy. Of fundamental importance is the fact that "hungry people" are not the central element in the world economy for food products. Moreover, the global environmental is probably becoming more, rather than less, difficult for solving hunger problems.

The 1970s represented a transition in the world food situation. This change consisted of many components, only two of which will be highlighted here.[5] One fundamental element centers around the demand for meat. Between 1960 and 1980, the amount of grain consumed globally by animals doubled, from 20% to 40% of total cereal production. In 1980, for example, more grain was fed to animals than consumed by the 1.4 billion people living in countries with per capita annual incomes of less than $250. Although the decade of the 1970s still saw many people mired in poverty, it also saw numerous groups and nations reach a state of affluence that involved greatly increased demands for meat. Such diverse nations as Nigeria, Taiwan, China, South Korea, and Mexico became major entrants into world feed grain markets.

The second major element of the 1970s, about which there is still great debate, involves events within the United States. At the present time and at present prices, there appears little excess capacity within American agriculture. Moreover, much of the recently utilized agricultural capacity has already been "exported." In 1970/71, the United States shipped 41 million tons of grain, which represented 37% of global cereal trade. By 1980, the export share had risen to 56% and to 118 million tons. With already large exports and with some evidence of stagnating productivity within agriculture, the next decade surely will see a reduction in the rate of export growth from North America. The decade will probably also see rising real prices of grain globally and increased price variability as well.[6]

[4] Section 5 of the *Report* deals specifically with hunger in America. The commission concluded that the Food Stamp Program had been effective in solving most hunger problems in the United States. It argued against restrictive budgetary ceilings on the Food Stamp Program and urged greater efforts in making sure that groups such as American Indians and the elderly were enrolled as participants. Space limitations preclude full development of the "hunger in America" portion of the *Report* in this essay.

[5] This view of the 1980s is developed much more fully in Falcon, Pearson, Timmer.

[6] The *Report* strongly urges an international agreement on grains that includes substantially increased reserves. However, the technical problems with international agreements and their recent history do not inspire confidence about the likelihood of their being successful in the 1980s. Moreover, any new grain agreement must be able to reconcile both North/South and East/

This is not an essay to develop fully a prognosis for the 1980s. However, the foregoing comments, cryptic as they are, have important implications for an assessment of the *Report* and for suggestions on future public policy on world hunger.

First, by not laying out more carefully a broader view of the world food economy of the 1980s, the commission failed to stress the increased likelihood of difficulties in solving hunger problems. Such a view of the world also would have given much more force to the commission's recommendations on trade, debt restructuring, compensatory finance, and food security.

Second, a more interdependent view of the 1980s (with respect to countries, commodities, and hunger/commercial issues) would have added support to the commission's theme on self-reliant production within low income countries.

Third, a broader view of the 1980s also might have permitted the commission to take a stronger stance on some areas in which the United States should be cautious—for example, highly subsidized corn-based ethanol plants.

Program Elements for the Future

Most of the commission's *Report* is as relevant for President Reagan as it was for President Carter. Global hunger continues to persist, and if anything, it is more likely to be a destablizing international influence in the future than it was in the past. At the risk of making very difficult issues sound superficial or the solutions seem easy, the case for a renewed American focus on hunger alleviation can be broken down into seven operational propositions. On the whole, these principles are consistent with the *Report*, although they also reflect personal preferences and the political changes that have occurred since the termination of the commission.

(a) Given an increasingly interdependent food world, the hunger topic is an appropriate focus for America's relationship with developing countries. Of all the broad areas in which the United States could play an important leadership role, food and agriculture would seem to be preeminent. The extraordinary productivity of American agriculture, the well-(indeed over-) fed character of the American people, and the dominance of the United States in the global food system give this country credibility in the food area as perhaps in none other. Moreover, a concern with the poor and malnourished, especially children, is very much in the American tradition.

These widely recognized points, however, may be necessary but not sufficient conditions for making hunger a central focus of development assistance. If hunger is poverty-related, as seems clearly the case, it is not a tidy area in which to involve an assistance program, nor is it the only important problem facing developing countries. Moreover, the vastness of the hunger problem may be out of balance with the size of America's aid commitment. Finally, it is abundantly clear that hunger issues go to the heart of the political economy of many nations. In some countries American concerns about hunger will go unheeded or be counterproductive, and in virtually all countries, most of the resources and difficult decisions will be of a domestic nature. Nevertheless, the hunger area seems to be one in which greater amounts of both public and private support can be mobilized within the United States.[7] More generally, food is a topic which, if not handled properly and expeditiously, could have far-reaching international consequences during the 1980s.

(b) A focus on hunger means a primary emphasis on agriculture and rural development. If hunger alleviation is made a focal point of American development assistance, such a concentration implies a concomitant emphasis on agriculture—but not for the reason that most people believe. Increasing food output is obviously important, especially in those societies with rapidly increasing populations and incomes. In terms of reducing hunger, however, the employment and income effects of agriculture are much more important than expanded food output per se. Although urban poverty and hunger may be more acutely visible, the overwhelming numbers of undernourished people are in the countryside. Many (perhaps 60%) of these individuals do not have direct access to land. These decentralized and

West negotiating stances. Under these circumstances, the United States probably can be of greatest assistance by helping less developed nations with the production, financial, and storage flexibility these countries need to accommodate international price instability.

[7] The Gallup Organization was employed by the commission to undertake a poll of Americans about world hunger. The results indicated a widespread misunderstanding of the severity and nature of PCM problems. They also showed that, in relative terms, Americans were very concerned about world hunger issues.

often forgotten groups are also among the hardest to reach with direct consumption programs within the public sector. In the absence of thoroughgoing agarian reforms, the key to reducing hunger problems is through additional productive jobs. The distinction between food production and income generation is an extremely important point—one often missed by agriculturalists and proponents of *Food First* (Moore and Collins). It also underscores the urgent need for choice of technique analyses based on social profitability rather than on preconceived notions of what should be considered "modern."

(c) A primary emphasis on agriculture means increased focus on relevant agricultural technology. In the commission's deliberations, the issue of agricultural technology was hotly debated. Part of the controversy had to do with the problems of tractors and mechanization in "labor-surplus" areas and part with the failures of introducing annual crops on delicate forest soils. Issues surrounding seed technology and the appropriate use of fertilizers and pesticides also fueled the debate. At least in part because of these controversies, the *Report* was largely silent on the importance or limits of agricultural technology in an assistance strategy for the United States. This silence may have been one of the most severe limitations of the commission's analysis.

In spite of much-heralded developments in wheat and rice, involving now some 50 million acres mainly in the irrigated regions of Asia, the overall record on improved seed technology is rather poor. New developments with open-pollinated corn varieties reengineered for tropical conditions will soon be available, and new packages for sorghum and millet also offer substantial prospects. There is active research underway as well for beans, cassava, and vegetables that promises to be relevant. Nevertheless, in assessing technology needs and accomplishments to date, it is clear that much research is needed, especially for rainfed agriculture. Fortunately, the general area of agricultural research is one in which the United States has a comparative advantage. Many of America's processes for developing technology are certainly relevant even if much of existing American technology is not directly transferable. Technology is also an area where both the public and private sectors in the United States have much to contribute, as do the universities—even some that do not belong to the land grant fraternity!

With a limited development assistance program, finding an appropriate niche for American involvement is extremely important. For example, land reform may be more vital than technology in alleviating hunger in some regions, but American efforts to promote agrarian reform in other countries are almost sure to be counterproductive. By avoiding some of the mistakes on technology that have occurred in the past and by recognizing that technology cannot solve all the problems of development, it should be possible to develop a large, positive program in this field. Fortunately, many of the relevant institutions (for example, the Consultative Group on International Agricultural Research (CGIAR) and the Board of International Food and Agricultural Development (BIFAD), are in a position to make this technological promise a future reality.

(d) For agricultural technology to be effective, large investments will be required, especially in such fields as water resource development. Presumably neither the Carter nor Reagan administrations have been particularly happy with the price tag that the commission attached to hunger alleviation. Unfortunately there are no "cheap fixes" on food and agriculture, and the commission called for a rapid tripling in the appropriations for foreign aid, much of which was to go for hunger causes. Particularly at a time when cuts in expenditure are the order of the day, such a recommendation requires further comment.

Although there always has been a limited lobby on foreign aid, it seldom draws the passionate support of many other allocations. In recent years, this problem has been accentuated by an unusual combination of political forces. Many on the political right have seen foreign aid as a costly giveaway to be stopped. The left has become so enamored with the "small-is-beautiful" syndrome that they have significantly downplayed the very real investment costs that will be essential if third world nations, with external assistance, are really to attack hunger. The net result has been an increased number of restrictions on aid allocations, such as on rural infrastructure, and a deceleration in the level of aid authorizations.

These effects can be seen in the official review of overseas development assistance published by the OECD. In 1979, for example, the United States ranked fifteenth among DAC countries in terms of its percentage of gross national product (GNP) devoted to bilateral and multilateral assistance to developing

countries. Indeed, with only 0.2% of GNP devoted to aid, the United States share exceeded only that of Italy and Austria among the seventeen nations that make up the Development Assistance Committee. The specific rationale for a larger American share will be discussed later, but a *prima facie* case for larger sums can be made just on the basis of the foregoing data.

Two cost components deserve special comment in the context of hunger. One of the severest problems in improving the nutrition of hungry people involves water resource development. The Asian concentration of hunger has already been mentioned. Moreover, by the year 2000, about half of the entire world's population will live in areas defined by the ten largest river basins in Asia. These basins, with their problems of irrigation, erosion, flooding, salinity, and drainage, contain many of the world's poorest people. Without some improved control over the production environment, the potential for new agricultural technology is limited. If unprecedented migration and other problems are to avoided, substantial investments will be needed to create dynamic rural communities where productive employment and incomes can increase. Most of the resource mobilization will have to be accomplished locally, but international resource transfer also is vital. Because many of the basin problems cross borders and involve several countries, outside agencies have a particularly crucial role to play. Regrettably, there is no cheap way out on this investment issue. People who want to attack hunger without significantly adding to the investment totals are kidding themselves or each other.

Second, for both the technology and water resource fields, there are important roles for both bilateral and multilateral initiatives. The *Report* underscores the complementarity of both approaches and urges strongly American support of the soft-loan window at the World Bank (IDA) and the international agricultural research effort the World Bank coordinates. Similarly, the commission's suggestions on debt restructuring are in the same general direction, since debt rollover in many instances is identical with increased flows of untied aid. While the investment needs are large, they are not beyond the capacity of the world to manage. The International Policy Research Institute (IFPRI), for example, suggests that an additional $7 billion investment annually (in 1975 dollars) during the decade of the 1980s would increase the annual world cereal output by nearly 200 million tons by 1990 (Oram et al.). This sum compares with the approximately $80 billion supplied to less developed countries in 1979 from external aid and loan resources.

(e) *For technology and institutions to pay off, a substantial reorientation in economic policy will be needed in less developed countries.* One seemingly curious feature of the *Report* is its simultaneous emphasis on trade and self-reliant growth. When put in a slightly broader context, however, this contradiction disappears.

The recent growth in world cereal trade has been very large; it has also begun to substitute for domestic stockholding. Whereas global cereal trade in 1980 was approximately three times larger than in 1960, ending world grain stocks in 1980 were absolutely smaller than in 1960 and only about half as large relative to annual production. For reasons alluded to earlier, some slowdown in the growth of trade can be expected, probably accompanied with rising and more variable international prices of grain. While cereal trade clearly will continue to be important for many "hungry" nations, the costs of an international "solution" to their food problem likely will be higher in the 1980s. This view of world trade thus provides a logic for an increased emphasis on domestic growth in agriculture to supply both food and employment.

Technology and investment provide two legs of the productivity triangle, while price and trade policy supplies the third. In general, low income countries tend to discriminate against the agricultural sector and to provide less than international prices to their farmers. For a long-run production solution, raising prices to farmers in many countries is absolutely essential. However, it is more than sheer neglect or urban bias that keeps governments from making this change. Higher food prices also mean lower real incomes, especially for poorer groups who may spend up to 80% of their incomes on food. This basic pricing dilemma—short-run consumption losses versus long-run production gains—needs to be recognized for the very real problem that it poses, even for the most responsible government. Too many analysts have been content to deal only with the production issue. Neither AID nor the World Bank, for exam-

ple, has been willing to do much in quantitative terms in support of consumption/nutrition projects or in aiding transition programs designed to put in place new food price policies. A sympathy toward this basic consumption-production dilemma and a willingness to use food aid and other types of development assistance toward new policies are critically needed-if the United States and other donors are to be helpful in solutions to the food problems actually faced by low income countries.

Unfortunately, the *Report* is largely silent both on the price-policy dilemma and the further complications this problem creates with respect to consumption programs. Untargeted programs, such as physical rations for everyone, have high relative resource costs in poor societies. On the other hand, the administrative problems involved in reaching only the poorest groups, especially in rural areas, are immense. Helping to resolve this dilemma will be a task on which agricultural economists can make an important contribution in the years ahead.

(f) It is in the economic and security interests of the United States to assist in hunger alleviation and in the creation of a more stable world food economy. The redirection and expansion of American assistance to help fight global hunger that is being suggested here raises the obvious question of whether such changes would be worth the price to the United States. The commission took the view that recommended programs would have little chance politically unless the suggestions could be shown to be rather directly in America's own interest.

Such a view will perhaps be abhorrent to humanists, but they will be pleased to know that the commission answered the self-interest question with an unequivocal "yes." The basis for this affirmative assessment was twofold. The first element stressed growing economies and trade, using rather traditional arguments. The second explanation, and by far the more important, stressed the national security implications of food. The fact that several of the nations with substantial hunger also have a nuclear capability was one aspect of the argument, but not the major element. More broadly, food in the 1980s was seen as a potentially destabilizing force—in the manner, if not the same magnitude, that oil had been in the 1970s. Lest that view be casually discarded, one need think only of recent food crises in Poland, Russia, Egypt, Kampuchea, and Ethiopia. Consumption (though not necessarily hunger) issues were central in each case, and in several of these examples, the potential for international conflict was clearcut. This broader view of security would seem to be a natural complement to the military expenditures that have taken on a heightened priority under the new administration.

(g) Given that hunger alleviation is in the self-interest of the United States, substantial changes will be required in American attitudes and capabilities for working with developed countries. If the United States chooses to make hunger issues the center of its development assistance effort, more than marginal changes will be required. Additional dollars will be needed in support of research and investment. The Agency for International Development will have to overcome its inadequacies in technical competence to deal with food and agricultural issues. The United States will need to seek new kinds of formal relationships with several key nations. Above all, the president and Congress will have to lead. Most of the leadership involves doing new things, but it sometimes involves not doing things as well—not attempting to use food as a political weapon, not promoting uneconomic gasahol installations, and not failing to recognize the severity of the hunger problems, even in countries whose governments the United States dislikes.

With a clearer sense of direction, the United States is now in a unique position to assist countries in helping to solve one of the worst problems of mankind. Without renewed efforts on the part of the United States and all countries, however, global hunger problems will become more acute and destabilizing before the end of the century.

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Reflections on the Presidential Commission on World Hunger: Discussion

Marcelo Selowsky

I have three sets of remarks. First, some general reactions to the President's Commission report, particularly the section on implications for the United States' effort to combat world hunger; second, some specific comments on Falcon's paper; third, some further thoughts.

My Reactions to the *Report*

First of all, the commission must be congratulated for forcefully stating a very important fact still not fully recognized: that hunger and low levels of consumption in poor countries and poor families will not be solved by increasing the aggregate world or country's supply of food. Chronic hunger results from a lack of purchasing power by poor countries and poor families when they compete for that aggregate world or country supply. The problem is not a lack of supply but a lack of effective demand by low income population groups. This is corroborated by the fact that many countries have become exporters of grains while important segments of their population still suffer from malnutrition.

The report singles out several actions to increase the long-run earnings opportunities of poor individuals so as to solve long-run poverty and thereby long-run hunger. This is welcomed. But in many countries, poverty elimination is an objective in its own right. For other countries a poverty elimination strategy, as a means to solving the hunger problem, may have political constraints or trade-offs with other objectives, such as long-run growth. However, in these latter countries, governments might be interested in solving hunger as a separate objective from general poverty elimination. Hence, they might be interested in more quick, direct, and cost-effective instruments to eliminate hunger. In my view, given that the objective of the commission was to address hunger and not poverty, a stronger emphasis on these direct instruments should have been given. This includes an emphasis on a better use of the existing foreign aid and domestic resources that countries are currently devoting to food supplementation programs, food subsidies, etc. I will come to this later.

The commission repeatedly refers to the necessity of a more self-reliant food system in developing countries. It is not exactly clear to me what is meant. I hope it is not a call for a higher degree of self-sufficiency in food. That would be tragic. Fluctuations in food consumption in poor families results from fluctuations in their regional supply of food or fluctuations in their earnings. Internal and international trade in food helps to even out these fluctuations in consumption and not the reverse.

Comments on Falcon's Paper

Wally Falcon's paper represents an interesting afterthought by a member of the commission, particularly in his further elaboration of the economics of the hunger problem. The paper presents several operational propositions to eliminate hunger. I do not have a particular quarrel with them; however, it is not clear whether these propositions represent facts or simply working hypotheses requiring empirical validation. A more explicit presentation of the economic criteria under which to accept or reject these hypotheses would have been useful. Let me give some examples by quoting some of these operational propositions.

"A focus on hunger means a primary emphasis on agricultural and rural development." The paper is careful to state that the relevant effect on hunger is via the income or earnings effect and not via the supply of food, i.e., it clearly recognizes purchasing power as

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These comments reflect the views of the author and do not necessarily reflect those of the World Bank.

the constraint. However, the income effects of agricultural and rural development are basically relevant to small farmers. How relevant are they for the landless and urban poor? Even if the hungry are concentrated among small farmers, the cost of raising rural incomes could be substantial if the rates of return on those agricultural investments are low. In that case subsidization of those investments will be required. The success of effectively reducing hunger through this strategy depends crucially on the rate of return to investments in small farmers. What is the empirical evidence on it?

"The key to reducing hunger problems [among the landless] is through additional productive jobs." This requires further elaboration; what are "productive" jobs? Why do we have today less than an "optimal" volume of "productive" jobs? Is this the result of market failures (i.e., gaps between shadow and market wages) or government interventions (i.e., taxes on agricultural exports)? Some elements of welfare economics are required in discussing such a proposition.

"A primary emphasis on agriculture means increased focus on relevant agricultural technology." But, what is "relevant"? What is the room for maneuvering for foreign aid in this field if technological choices are heavily influenced by wrong domestic (factor) price policies?

"For agricultural technology to be effective, large investments will be required, especially in such fields as water resource development." But, what is the evidence on the rate of return to investments in water development? If it is high, why have countries not done it? Is it because there are strong discrepancies between private (or government-perceived) returns and social ones, i.e., short government horizons?

In my view a useful way to organize these policy choices is to set up first an acceptable criteria in welfare economics: how to increase food consumption in poor families, (*a*) given fiscal constraints on aggregate subsidies and, (*b*) minimizing any trade-off with efficiency and growth. The general option emerging is a policy that maintains world prices to food producers but brings down consumer prices for malnourished families. Why would subsidies on investment in water or rural job promotion be better? Specific discrepancies between social and private signals in those sectors must be identified before making judgments on their desirability.

Some Further Thoughts

I believe that the highest payoff in an effort to reduce chronic hunger comes from increasing the effectiveness of existing food aid and domestic food programs and food price subsidies. This is particularly true in countries already spending considerable resources on such programs. There are two areas to examine.

The first is to evaluate whether many of the existing international food aid programs, as well as domestic programs, have effects on food consumption no larger than an equivalent foreign exchange or income transfer. If governments are already importing grains, part of the concessionary food aid will replace old imports. The net addition to the internal supply of food will be equal to foreign exchange transfer times the public sector's marginal propensity to import food. The same is true for some typical domestic programs distributing inframarginal amounts of food, e.g., ration shops. If these marginal propensities (on the part of governments or poor households) are low, it is worth looking for changes in the ways these programs are being implemented (for a given amount of aid or domestic food subsidy). Food aid could be made contingent on the country keeping its old level of food imports constant. Similarly, food stamp programs charging a price equal to previous levels of consumption but offering a stamp value in excess of that level would be substantially more effective per dollar of subsidy.

In several countries substantial subsidies are being concentrated on a few food commodities therefore inducing important substitution effects. The net effect on calorie intake is not at all obvious and depends on the gross cross-elasticities among these foods. We still do not know the magnitudes of several of these key elasticities. The problem becomes more difficult when programs introduce new foods, i.e., baby foods, fortified cereals, etc. Here substitution effects cannot be measured with past data, and experimental data becomes of relevance.

Reflections on the Presidential Commission on World Hunger: Discussion

T. N. Srinivasan

I will organize my remarks around the following broad questions: First, has the Commission diagnosed the malady of hunger correctly and reasonably accurately estimated its dimensions? Second, has it arrived at appropriate policy recommendations, based on currently available knowledge? Third, are the recommendations balanced in terms of relative emphasis on policies to be pursued by individual countries versus international policies, on production versus distribution, on self-sufficiency versus dependence on international markets, and indeed, on reliance on markets in general versus government interventions?[1]

The Commission was misled in its diagnosis by its adoption of the analytical framework of Reutlinger-Selowsky. This and the earlier studies in India by Ojha, and Dandekar and Rath are based on improper use of the protein and calorie requirements put together by the United Nations Food and Agriculture Organization (FAO) for assessing undernutrition. Of course FAO had clearly warned that comparisons of recommended intakes with food consumption "cannot in themselves justify statements that undernutrition or overnutrition is present in a community or group as such conclusions must always be supported by clinical or biochemical evidence" (FAO 1973). I have discussed some of these issues in a paper published last March (Srinivasan). The essential point is that an individual, while remaining in good health, maintaining body weight, and performing activities that require the same energy expenditure, is nevertheless found to vary his energy intake over a wide range. In addition, individuals adapt to sustained heavy or low intakes by adjustment in body weight and/or physical activity. Further, as Sukhatme has shown, the daily energy balance, i.e., the difference between energy intake and energy expenditure, appears to follow an autoregressive stochastic process. Because of this autocorrelation, even the average of intakes over a week, or even a month, does not adequately dampen the variation in intake. In such a situation, comparing average intakes with the average "requirements" to determine the nutritional status of a group of individuals is dubious even if the group is homogenous in age, sex, body weight, and energy expenditure on physical activities. Indeed, available studies, such as those of Ferro-Luzzi et al., show that clinical evidence of undernutrition and nutritional inadequacy, as judged by shortfall in intakes compared to requirements, does not match. Controlled experiments by Edmundson, with similar individuals given diets of differing calorie content, demonstrated that energy expenditure adjusts to intakes without changes in body weight or physical activity through changes in efficiency of conversion of energy intakes into usable energy.

The comparison of average intakes with "requirements" often overstates the extent of real malnutrition; Bhalla, using U.S. data, shows that such a procedure classified more than 50% of the U.S. population as undernourished. If rough allowances are made for intra- and inter-individual variations in intakes, the estimated extent of undernutrition in a population often comes down substantially. Sukhatme's estimate of undernutrition in India is of the order of 15%–20% of the population and not the 50% or more as unadjusted estimates would suggest. Whether or not a reduction of this order should be called fine-tuning, as Falcon suggested, exaggerating the numbers of undernourished would only make the already difficult problem appear insolvable. In addition, it attributes the prevalent malnutrition to inadequate calorie intakes,

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[1] I confess I read only the thirty-page summary of the Commission's report. Reading Falcon's paper assured me that the summary is fair and has not omitted any essential features. However, if any of my critical remarks are adequately answered in the full report but not in its summary, I apologize to Falcon and through him to the other Commissioners.

whereas in fact morbidity caused by gastrointestinal and other ailments arising out of unsafe drinking water and poor sanitation is perhaps equally or more important as proximate cause.

The Commission's diagnosis that over the longer term hunger can be eliminated only by eliminating its causes—poverty and insecure food supplies—is not wide of the mark, though it is hardly original. However, the Commission does not appear to have looked into the experience of some developing countries where, in spite of poverty, very creditable achievements in the area of nutrition and health have been recorded; and of others at the other end of the spectrum where, in spite of relatively high per capita income of the country, significant sections of the population are deprived. Sri Lanka and Kerala State in India fall into the former category and Northeast Brazil into the latter.

The Commission emphasizes that the elimination of hunger is in U.S. national security and economic interest. As such, the United States should make it the major focus of its relationship with the developing world. Falcon apparently agrees. But the national security angle, like the earlier use of the Communist threat as an argument for economic aid, is unlikely to impress many congressmen or senators, let alone the U.S. public at large. The fact of the matter is that, as Dr. Falcon himself notes, the poor and hungry are rarely the wielders of political power in any country. The power elite, in spite of their rhetoric, do not often perceive it to be in its self interest to divert resources to the poor and hungry.

The recommendations that the United States should work toward multilateral reductions in tariffs and nontariff barriers to LDC exports is, of course, unexceptionable. But whatever it may do to augment the exports of LDCs and improve efficiency of world resource allocation, its impact on the poor and hungry is not that direct. The same is likely to be true of commodity agreements that attempt to stabilize or increase export revenues of LDCs, assuming for a moment (contrary to experience) that they do succeed in doing so. It is not often the case that export crops are produced by small farmers. Debt write-off and raising the grant element in U.S. aid are also laudable, but again the link with the elimination of hunger is at best tenuous. However, all these recommendations and the exhortation that the United States raise its development assistance to 0.7% of its GNP are non-starters in today's climate, if ever they were.

The Commission recommends that the United States should give assistance primarily to countries meeting the basic needs and rights of the people. I am afraid that any direct linking of bilateral aid to specific domestic policies will be viewed by recipient countries as unwarranted interference in their domestic affairs. In an increasingly complex economy, it is possible that investment in infrastructure may be more productive and will help reduce poverty more than direct investment in food production, at least in some countries. Thus, excessive emphasis on meeting basic needs and rights in the short to medium run may go against meeting them in a sustainable way in the long run.

The Commission also recommends that the United States should put more emphasis on nutritional goals. Apart from the difficulty of defining the problem, assessing its extent, identifying its causes, and prescribing solutions, there are several other operational difficulties, some of which are identified by Falcon. It is not as if there have been no attempts to identify subpopulations at risk, such as children, pregnant and lactating mothers, and to target programs toward these groups. The applied nutrition program and the scheme for the midday meal for school children in India indeed were such programs. These were initiated long ago and are still being implemented. Studies evaluating these programs are also available. Had the Commission looked at this experience, they would not be so optimistic about achieving nutritional goals. Simply put, a major problem, mentioned by Falcon, is that because the household is the decision unit, any provision through the government of food designated for one member of the household—be that person a school-going child or a pregnant mother—will result in that member being supplied less from the household pool. Thus, even though the government supplies food to the target members of the household, the food more or less acts as an income supplement to the household as a whole. The target group members will not receive full benefit.

The Commission recommends that more research be done in the United States on improving agriculture in the developing countries. I would rather have recommended technical as-

sistance to LDC research institutions. In this way the research capability in the LDCs will be strengthened.

The Commission appears to me to be "dirigé" in its approach, in that it has inadequately emphasized the role of markets. The approving reference to self-sufficiency as a goal for each LDC leaves the impression that the Commission does not think much of comparative advantage. The minutes of dissent indicate that some Commissioners wish to go even further and embrace the proposals of some radical LDC economists by suggesting that the LDCs "delink" from the developed world. They recommend that U.S. aid and food aid be stopped altogether in the hope that it would force LDC governments to pursue what they call "basic needs"-oriented policies. Apart from the lack of content or coherence of a "basic needs" strategy of development—if one can indeed define such a strategy—the naivete or, worse still, cold cynicism behind such a proposal is appalling. They ought to know that any delinking and cutback in aid is certain to hurt the poor and hungry more than any other group.

The Commission has not emphasized enough the basic fact that what really matters from the point of view of elimination of hunger are the domestic policies and institutions that govern resource allocations in agriculture, as well as income distribution within agriculture and in the economy in general. There is no easy or quick-fix solution to institutional reform. Nor is it simple to state the extent to which U.S. policies can aid or retard needed reforms. Good intentions and generalities are no substitutes for policies based on realistic assessment of the feasible, in specific, contexts.

Finally, the Commission could have explored further the implications of the emerging trends in international trade in food grains such as the following: (*a*) the increasing importance of middle income countries and oil exporters in the market for food grains, (*b*) the fact that these countries and the Soviet Union wish to import grain for expanding their livestock and increasing meat supplies, (*c*) the already concentrated grains market is becoming further concentrated in terms of few supplier countries and companies facing importers, some of whom are state trading organizations, (*d*) the disappearance of U.S. food stockpiles that stabilized the trade in the sixties, and (*e*) the impact of the energy crisis on the prices and supply of chemical fertilizers on which any substantial growth in food output in LDCs depends. Each of these factors has serious, possibly adverse, implications for the elimination of poverty and hunger.

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Economic and Environmental Consequences of U.S. Agricultural Trade Policy (George E. Rossmiller, Foreign Agricultural Service, USDA, Presiding)

Toward a U.S. Agricultural Export Policy for the 1980s

Alexander H. Sarris and Andrew Schmitz

In a recent issue of *Business Week*, a special article on the restructuring of the American economy paid particular attention to the agricultural sector and how it likely would be the prime fuel for inflation in the 1980s. The rationale behind this outlook was the projection that international demand for U.S. agricultural exports would continue to grow rapidly, while a combination of slower domestic agricultural productivity growth and sharply increased production costs would temper a contemporaneous increase in output. The article concluded by saying that "we certainly will need a federal policy on exports and in the next few years there is going to be an intense debate on that" (p. 74). The purpose of this article is to open such a debate on an appropriate U.S. agricultural export policy for the 1980s.

For the last decade, agricultural exports have comprised on the average roughly 20% of the total value of U.S. exports. Agricultural imports, on the other hand, have sharply and continuously declined in relative importance over the same period, from 15% of total U.S. imports in 1970 to 7% in 1980. The result has been a sharply growing agricultural trade surplus (from $1.5 billion in 1970, to $12.6 billion in 1975, to $23.9 billion in 1980) compared to a widening nonagricultural trade deficit (always in the red in the last decade and sharply increased in the last five years from −$20.7 billion in 1976 to −$47.2 billion in 1980).

U.S. agricultural exports are largely concentrated in grains (42.6% of the total agricultural export value in 1979–80), soybeans and products (24.1%), and cotton (6.7%), while a variety of animal products and tobacco comprise the major part of the remainder. U.S. agricultural imports, on the other hand, are less concentrated. Noncompetitive items with U.S. production, like coffee, cocoa, rubber, and bananas, make up 41.8% of imports in 1979–80. Among the supplementary imports, the largest shares are occupied by beef and veal (18.9% of total supplementary imports by value in 1979–80) and sugar (14.9%), the remainder being comprised of a wide variety of products.

Of particular importance to trade and the American balance-of-payment position is the growing share of U.S. agricultural production that is exported. Table 1 shows proportions of the major agricultural products and the share of total U.S. agricultural production exported from 1965–66 to 1978–79. Currently, about half of the total agricultural production is exported, while a decade ago the proportion was about one-third. The growing importance of trade for U.S. agriculture has implications that must be reckoned with in the 1980s.

Production Expansion to Meet Foreign Demand

In a recent series of policy papers (U.S. Department of Agriculture 1980a), the emphasis has been placed on increased U.S. agricultural production to meet the growing demand from abroad. Where is this growing demand bound to come from? Table 2 presents the United Nations, Food and Agriculture Organization (FAO) projections of increases in world export availabilities and import requirements for the major U.S.-traded products for 1985. An important conclusion that these data support is that the major new markets for expanded U.S. agricultural exports (and, in particular, grains, oil seeds, and cotton) will be the developing countries, while the importance of many traditional markets, such as Western Europe, other developed economies, and the USSR will decline in relative terms.

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Table 1. Proportion of Yearly U.S. Production of Major Products Exported (Percentage of Total Quantity) and Value of Agricultural Production and Exports

	1965–66	1970–71	1974–75	1978–79
	(%)			
Grains[a]	26.1	20.1	33.4	36.5
Soybeans	28.9	36.9	35.3	38.1
Cotton	31.1	33.7	34.9	53.9[b]
Value of agricultural production ($ million)	17,944	21,626	48,620	58,151
Value of agricultural exports ($ million)	6,387	7,240	21,436	29,633
Share of agricultural exports in total agricultural production (%)	35.6	33.5	44.1	51.0

Source: U.S. Department of Agriculture 1980b.
[a] Includes wheat, rice, corn, rye, oats, sorghum, and barley.
[b] 1978 only.

What are the costs of expanding U.S. agricultural exports? Is a policy aimed at increased production only one more means by which importers operate in a trading environment where buyers rather than sellers dictate the terms of trade? The key issue here is the nature of comparative advantage for the United States when price supports, research and development expenditures, subsidies, etc., are taken into account (Edwards and Freebairn).

The United States and other grain exporters, such as Canada and Australia, are promoting all-out production to meet demand from abroad. Consider a policy which increases production through increased expenditures on research and development. In figure 1 domestic demand is D_d, and foreign demand is D_f. With a supply surve, S', exports are OQ_1. Now what are the effects of investing in research and development which yields a technological change such that S_t results? Quantity of exports expands to OQ_2, and total export value becomes OP_2bQ_2 which is larger than OP_1aQ_1 if the export demand curve is reasonably elastic. Who are the gainers from the push toward production expansion? While the consumers in the exporting country gain $P_1a'b'P_2$, the foreign consumers gain P_1abP_2, which is even larger, since export demand is such a large share of total demand. The producers' gain, $p_2gh - P_1ef$, is positive if the supply shift is parallel. However, if the shift makes the supply curve more elastic, the producers could certainly lose, and the loss could even exceed what the domestic consumers gain.

Also, note that exports have increased in

Table 2. Projected Net Changes from 1975–77 to 1985 in World Export Availabilities and Import Requirements for Major Commodities

Product	Changes in Export Availabilities: North America	Western Europe	Eastern Europe and USSR	Other Developed Countries	Developing Countries	Changes in Import Requirements: North America	Western Europe	Eastern Europe and USSR	Other Developed Countries	Developing Countries
	(thousand metric tons)									
Wheat	4,876	1,470	1,204	2,004	2,468	0	−2,067	−3,102	1,066	9,966
Rice	653	135	0	76	1,054	29	−37	−256	54	2,431
Coarse grains	20,115	364	2,725	1,517	263	−98	1,534	−5,737	6,485	24,624
Meat	21	422	242	589	509	356	−256	−183	211	1,834
Milk and milk products	−418	8,217	1,188	−105	344	−155	−2,535	−322	946	9,675
Fats and oils	1,010	0	900	−120	2,930	0	80	−70	640	4,160
Oilcakes and meals	970	−80	0	−70	2,030	−30	730	1,130	740	200
Sugar	0	240	145	705	3,400	835	−825	−1,800	550	3,700
Cotton	483	−15	69	5	−64	−2	−54	69	53	627
Tobacco	91	31	−8	0	218	0	−2	64	85	113
Citrus fruit	−363	639	0	−116	4,302	388	688	643	68	757
Cattlehides/calfskins	62	27	0	29	176	0	29	−17	84	210

Source: United Nations, Food and Agriculture Organization.

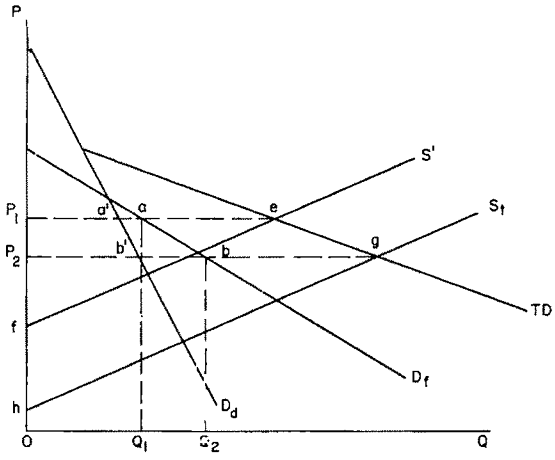

Figure 1. Increased production via research and development in international trade

both quantity and value terms, but there has not been a shift in foreign demand in the sense that the schedule, D_f, has shifted to the right. The true statement is that exports have increased both in terms of quantity and total value because of policies in exporting countries which have lowered the real price of food exports. In terms of data, if P_1Q_1 and P_2Q_2 were observed over time, one cannot necessarily conclude that there has been a growth in exports in that they have grown at some constant real prices; exports could have increased because of lower real prices. It is clear from figure 1 that policies can be introduced which result in an increase in exports, but the benefits from such policies can go largely to importers. A country should not necessarily be proud of the fact that its exports are expanding!

There may be an important reason why exporters are pushing for increased production. Given the current political climate, Australia, Canada, and the United States are competing for export markets (McCalla, Schmitz, Storey). As a result, Canada, for example, to maintain its export market share, also has to push for increased production, which it has recently done by trying to increase production by 30% above past levels.

From the above analysis and data, the conventional wisdom, as expressed in the quoted *Business Week* article, that there are vast and growing international markets for U.S. agricultural products should be interpreted with caution. This growth might not occur if the marginal cost of production expansion in the United States had to be covered by the marginal return from the export market. Second, the uncertain question that emerges is whether the developing countries, as a whole, can afford to purchase in the international market the immense quantities of food and feed crops that they will no doubt require, given that many of these nations face acute foreign exchange shortages because of the energy crisis and already heavy external indebtedness. A further unknown factor is whether the various efforts toward food self-sufficiency via intensification and technological adaptation methods in agricultural production in those countries will significantly modify downward the already-mentioned FAO import requirements (cf. table 2).

Another factor that should temper the unfettered optimism of those that envision everexpanding U.S. agricultural export markets is the rising agricultural protectionism in the major developed importing countries in the recent years. In the EEC, for instance, Sampson and Snape and Jabara showed that in the last few years the ad valorem tariff equivalent of the variable levies is approaching the levels of the early 1970s after a period of low protective levels. This rising relative protectionism is not the result of increased political power of farmers in many countries. It is rather the result of generally softer world markets (partly because of larger U.S. export supplies) coupled with fixed nominal agricultural internal price levels. It is probably not farfetched to assume that in the early 1980s the world agricultural scene presents a similar degree of "Disarray," as Johnson computed for the early 1970s.

Is Instability Going to be the Villain?

The trends analyzed above, namely, the increased share of U.S. agricultural production that is exported and the projected relative shift of U.S. agricultural export markets toward the developing countries combined with the openness of the U.S. market, suggest that the real serious problem in the 1980s could well be a growing instability in the agricultural sector. Large price fluctuations in the agricultural sector can lead just as easily to inflation as can continued shortages. The 1972–75 commodity price boom provided an example of how inflation can follow from commodity instability (Cooper and Lawrence).

To analyze how the changing structure of

the market for U.S. exports (as suggested by table 2) impinges on domestic price stability, consider a simple model for one commodity. Let domestic supply, domestic demand, and demand for exports be given by the equations:

$$S = S_0 p^{\alpha} u, \tag{1}$$

$$D = D_0 p^{-\beta} v, \text{ and} \tag{2}$$

$$E = E_0 p^{-\gamma} w. \tag{3}$$

In equations (1)–(3), S_0, D_0, and E_0 are the base period quantities of domestic supply, domestic demand, and exports, respectively; p is the domestic price (equal to the international one) which is equal to one in the base period; u, v, and w are multiplicative random disturbances with means equal to unity, uncorrelated over time, and independent (for simplicity); and α, β, and γ are all positive constants equal to the short-run price elasticities of domestic supply, domestic demand, and export demand, respectively. The short-run market equilibrium condition that determines the equilibrium price is

$$S = D + E. \tag{4}$$

Denote by S_d, S_f the base-period shares of total supply that are absorbed by the domestic market and exported, respectively ($S_d + S_f = 1$), and by x^*, the proportional change of a variable from its basic value ($x^* \equiv dx/x_0$). The differentiation of equation (4) leads to the following expression for the short-run proportional price shift:

$$p^* = \frac{S_d v^* + S_f w^* - u^*}{\alpha + S_d\beta + S_f\gamma} = \frac{v^* - u^* + S_f(w^* - v^*)}{\alpha + \beta + S_f(\gamma - \beta)}. \tag{5}$$

Denoting by σ_v^2, σ_u^2, and σ_w^2, the variances of v, u, and w, respectively, the variance of the proportional short-run price fluctuations (to be denoted by σ_p^2) can be written as

$$\sigma_p^2 = \frac{\sigma_v^2 + \sigma_u^2 + S_f^2(\sigma_w^2 + \sigma_u^2) - 2S_f\sigma_v^2}{[\alpha + \beta + S_f(\gamma - \beta)]^2}. \tag{6}$$

It is immediately evident from (6) that $d\sigma_p^2/d\gamma < 0$. In other words, if the price elasticity of demand for U.S. exports becomes smaller, then this will lead, *ceteris paribus,* to larger domestic price fluctuations. It has been observed as well as formally analyzed (Abbot, Sarris 1980) that the import demand of developing countries is highly price inelastic because of government interference in both domestic and external trade. If the destinations of U.S. agricultural exports become dominated by developing nations, as seems to be the trend, then the weighted price elasticity of demand for U.S. exports will diminish leading to increased domestic instability.

Assuming now that domestic demand fluctuations are miniscule compared with domestic supply and foreign excess demand disturbances, we can obtain from (6) a simple expression for the derivative of the domestic price variance with respect to the proportion, S_f, of domestic production that is marketed abroad:

$$\frac{d\sigma_p^2}{dS_f} = \frac{2\sigma_w^2(\alpha + \beta)}{[\alpha + \beta + S_f(\gamma - \beta)]^3}\left(S_f - \frac{\gamma - \beta}{\alpha + \beta}\,\frac{\sigma_u^2}{\sigma_w^2}\right). \tag{7}$$

Equation (7) suggests some interesting speculations. First, if $\gamma < \beta$, namely, if the price elasticity of foreign demand is lower than the price elasticity of domestic demand, then the expression in (7) is positive, suggesting that an increased foreign exposure of U.S. agriculture will imply increased domestic price instability. Given the extensive foreign government intervention in agricultural trade and the shift of U.S. exports toward more price inelastic developing countries, the hypothesis that γ is smaller than β does not seem farfetched. However, even if $\gamma > \beta$, then, as table 3 indicates, it is mostly for values of the ratio γ/β much larger than one that the possibility of a negative sign of $d\sigma_p^2/dS_f$ becomes real. Furthermore, it is much more plausible to hypothesize that foreign demand fluctuations are much larger than domestic ones. Looking down the columns where σ_u/σ_w is equal to .5, it can be seen that only when γ/β reaches 5—a rather farfetched possibility—does the sign of $d\sigma_p^2/dS_f$ become negative.

The above analysis suggests that, given export and market trends, a major problem for U.S. agriculture in the 1980s will be increased instability and not secular rises or declines in product prices.

Multilateral Reductions in Trade Barriers

Traditionally, the United States has advocated free trade in agricultural exports. At the same

Table 3. Sign of $d\sigma_p^2/dS_f$ for Different Values of Price Elasticities, Supply and Export Fluctuations, and Foreign Trade Dependence

	S_f	.3			.4			.5			.6			.7		
γ/β	α/β \ σ_u/σ_w	2	1	.5	2	1	.5	2	1	.5	2	1	.5	2	1	.5
1.1	2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	.5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	.2	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1.3	2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	1	−	+	+	−	+	+	−	+	+	−	+	+	+	+	+
	.5	−	+	+	−	+	+	−	+	+	−	+	+	−	+	+
	.2	−	+	+	−	+	+	−	−	+	−	+	+	−	+	+
1.5	2	−	+	+	−	+	+	−	+	+	−	+	+	+	+	+
	1	−	+	+	−	+	+	−	+	+	−	+	+	−	+	+
	.5	−	−	+	−	+	+	−	+	+	−	+	+	−	+	+
	.2	−	−	+	−	+	+	−	+	+	−	+	+	−	+	+
2.0	2	−	−	+	−	+	+	−	+	+	−	+	+	−	+	+
	1	−	−	+	−	−	+	−	0	+	−	+	+	−	+	+
	.5	−	−	+	−	−	+	−	−	+	−	−	+	−	+	+
	.2	−	−	+	−	−	+	−	−	+	−	−	+	−	−	+
5.0	2	−	−	−	−	−	+	−	−	+	−	−	+	−	−	+
	1	−	−	−	−	−	−	−	−	0	−	−	+	−	−	+
	.5	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+
	.2	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

time, however, supplementary U.S. agricultural imports, as well as principal exports, have been subjected to sizable trade barriers. For the former, Wipf computed that the total effective rate of production for sugar and syrup products in 1968 was 660%, while for dairy products it was 48%. Price supports for food grains and cotton in 1968 resulted in effective protective rates of 143% and 101%, respectively.

While the commodity boom of the mid-1970s reduced the effective protection rates to almost zero for most products, the recent years have seen a resurgence of U.S. protectionism. The yearly average differences between the United States and international sugar prices have been 14.7%, 34.3%, and 78.4% in 1976, 1977, and 1978, respectively. Wheat and feed grain payments to producers under CCC programs have reached $2 billion in 1978 compared to $360 million in 1975 and $330 million in 1976.

Table 4 gives some recent estimates of increased imports from free trade in selected products in the United States and the major U.S. foreign markets. Note that, for two of the most highly protected U.S. commodity categories—beef and dairy products—the aggregate losses to the United States from free trade (i.e., increased imports) are much less than what the United States would gain from export expansion due to trade liberalization abroad. This can be seen merely by looking at the projected increased imports of Japan alone and by considering the fact that the United States enjoys an 80% share in Japanese feed grain and soybean imports and a share close to 50% in some of the other products.

It may well be that importers of U.S. products are unwilling to lower trade barriers because the United States is unwilling to do so. Yet, as table 4 shows, it is certainly in the best interest of the United States to move to freer trade because the losers from more liberal trade could easily be compensated by the gainers, so all could be made better off.

In certain commodities the United States has, in fact, been unwilling to grant domestic producers protection through tariffs. For example, in the 1979 Mexican vegetable-dumping lawsuit filed by Florida producers, the United States ruled in favor of Mexico; hence, tariffs were not misused on Mexican exports of fresh winter vegetables to the United States (Schmitz, Firch, Hillman).

Importers of U.S. agricultural products, such as Japan, may have good reason to favor protection other than for the often-heard ar-

Table 4. Alternative Estimates of Increased Imports Resulting from Complete Removal of Agricultural Trade Barriers

Importing Area and Products	USDA	FAO	Cline et al.
	($ millions)		
EEC of nine			
Beef	1,022	[a]	135
Wheat	646	1,275	411
Feed grains	1,935	1,322	843
Soybeans	1,005		0
Total, four products	4,608		1,389
Japan			
Beef	6,199		42
Milk, dairy products	5,109	169	50
Wheat	90	80	234
Feed grains	1,623		45
Soybeans	889		0
Total, five products	13,910		371
United States			
Beef	−189		98
Dairy products	929	1,420	76
Total, two products	740		174
Total, three importing areas	19,258		1,934

Source: Schmitz et al., chap. 7, p. 231.
[a] Blanks indicate not available.

gument that protection is used to increase income of farmers. Studies have shown that tariffs do more than just protect farmers—they result in a welfare improvement for the country as a whole because the producer gains plus the tariff revenue more than offset the consumption losses. For example, Carter and Schmitz have shown that, for wheat alone, major importers have gained roughly $3.7 billion per annum from pursuing close to optimum tariff policies.

In addition to optimal tariff policies used by importers of U.S. goods, exporters to the United States may also be using their trade policies to their advantage. For example, Australian exports of beef to the United States are restricted by the use of voluntary quotas. Theoretically, one can show that the use of such quotas can give exporters monopoly power. If the exporter is able to collect the quota rent, it can, in essence, impose an optimal export tax by using a voluntary quota. Quotas can allow exporters to behave in a cartel-like manner against importers. The empirical results by Dodge suggest that this is what is happening with respect to exporters of beef to the United States. Thus, it may well be that importers of U.S. goods exert, consciously or not, monopsony power in buying; and exporters to the United States exert monopoly power in selling. This is certainly the worst of all possible worlds for the United States to be in. If this is true, it might offer another reason that countries who trade with the United States are resistant to alter substantially their trade policies.

Would the United States be willing to lower its agricultural trade barriers if its trade partners agreed to lower theirs? It would certainly be the best economic policy to pursue. Two recent developments seem to suggest that the United States could be more eager to do so in the 1980s. First, the income position of U.S. farmers, which always provided the rationale for restrictive policies, has improved considerably. While the average per capita disposable income from all sources of farmers stood at 71% of the average disposable income of the nonfarm population during 1965–70, the proportion in 1975–79 was 91%. Second, consumer interests are becoming much stronger politically and much more aware of the huge costs of past farm programs which only resulted in higher food prices.

Implications for Agricultural Trade Policy in the 1980s

It goes without saying that the United States has a dominant position in world agricultural trade. This position is bound to become more important, given the projections of table 2.

With this degree of market power, the relevant question becomes whether the United States can or should use this power to its advantage.

This issue and the desirability of production expansion in exporting countries, which was questioned earlier, are encountered in discussions of the implementation of a grain export cartel. In a forthcoming book (Schmitz et al.), it is demonstrated that production may have to be curtailed—at least in the short run—for optimal pricing to be achieved by exporters. In the long run this need not be the case. Given the tariff protection afforded high income importers, to be initially effective a cartel may have to reduce exports and production. Then, if importers respond, production may increase due to the movement toward free trade.

One of the key components of a cartel is cooperation among exporters. While the issue is important for wheat, it is much less important for feed grains because the United States is the major exporter. For a grain cartel to be effective, the United States, Canada, and Australia must have a cooperative production and export policy. As pointed out earlier, these countries currently seem to have a competitive strategy—a situation which importers enjoy immensely! The idea of a cartel is to gain rents from importers which the latter currently obtain from optimal tariff policies. As shown earlier, a policy among exporters of increased production to meet increased export demand does the opposite. Instead of raising price and total revenue (net of subsidies, etc.) as a cartel would, current policies lower price and reduce rent. Current policies only add to the buying power of importers.

In terms of export policy, a conflict arises between the domestic sector on aggregate versus producers. As Carter, Gallini, and Schmitz demonstrate, a government export cartel, which considers both producers and consumers jointly, is quite different from a producer export cartel established to maximize only producer returns. In the government cartel case, food prices are kept relatively low for domestic consumers. This is done by pricing grain for both food and feed uses below that charged to high income importers. This helps keep meat prices low as well. A producer cartel, in turn, will tax both domestic and foreign consumers.

While cartel-like policies might put pressure on high income importers to lower trade barriers, the United States must be considerate of developing country needs. Unless these countries can increase their agricultural exports (as Valdès and Zietz demonstrate, they could benefit considerably from OECD agricultural trade liberalization), a grain, and especially a food grain, cartel might contribute toward further balance-of-payment difficulties for them.

While production restriction policies could result in a situation where the United States could exploit fully its international market-size advantage, such policies could increase domestic price instability. As Sarris (1981) demonstrates, in such cases a buffer stock policy operated solely by the exporter with a stabilization objective could result in both higher expected welfare for the exporter and lower price variance than an optimal export tax policy. Given the likelihood of increased instability in the 1980s, a buffer stock policy operated by the United States could afford the best welfare *cum* stability outcome possible. A buffer stock, however, should not be the result of secular overproduction and used to support farm income as was the case in the late 1960s and early 1970s. It should have a clear stabilization objective which can be shown to help both producers and consumers. The farmer-held reserve provided a good example of such a stabilizing stock policy.

Cartel and buffer stock policies might not be as good as multilateral trade liberalization. However, unless the United States decides to lower its own agricultural trade barriers, not much should be expected from its partners. In such a situation, unilateral actions might be the only ones that serve producers as well as consumers in an equitable manner.

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Interrelationship among Export Markets, Resource Conservation, and Agricultural Productivity

Earl O. Heady and Cameron Short

The growing export market for U.S. farm commodities, especially grain, over the last decade has become the basic source of modern farm prosperity. While the public invested in a multibillion dollar supply and marketing control program over several decades to provide agriculture an equitable share of national income, the effects were somewhat minute in improving farm prosperity and asset values compared to the quantum jump resulting from greater exports since the early 1970s. The sources of these increases, greater incomes and populations of developing countries, institutional changes causing the Soviet Union and China to enter Western markets, and generally higher per capita incomes and meat consumption the world over, has—barring the negative fallout of major wars—the prospects of furthering the demands for U.S. grain and food exports. This newly acquired prosperity and wealth for agriculture in the immediate future does not necessarily promise a continued payoff for the next generations of farmers. There are two potential reasons that maintenance and further growth may not benefit equally the next generations. One is the tendency of current generations to capitalize the future growth in demand and income for U.S. agriculture into present land values. They have already "banked" this future return to an extent that the current return on land investment is very low. While numerous agricultural economists have proclaimed that exports and export policies are the significant future issues of agriculture (Schuh), this is true mainly for farmers who are land owners and have been or will be able to take advantage of the tremendous inflation in land values, resulting from general inflation and the growth in export demand and domestic commodity prices, and realize huge gains in their asset values. Of course, their descendents who inherit these enhanced asset values similarly will gain. If land prices "inflate forever," owners of farm land and their offspring will continue to "gain forever," just as will holders of gold and scarce works of art if they "continue to inflate forever."

Without this "forever inflation," and with a long string of growing future incomes already capitalized into land values, future purchasers of these assets will not find "exports the magic secret to farm prosperity." Farmers then may realize a low return on resource values generated from current earnings, just as are current farmers, who also have a mammoth capital gain increment to augment operational income. Farmers of the 1920s, 1950s, and 1960s complained mainly because they realized a low rate of return on their resources. New purchasers of land are faced with exactly the same problem. The American Agricultural Movement, as its members capitalized enhanced exports future prices into land values and pressed for price supports which would maintain corresponding asset values and returns, conducted the most violent demonstrations ever staged by U.S. farmers. Prospects are that farmers of the year 2000 will still be claiming low resource incomes and the need for higher support prices. Growing exports and export policies give no promise of eliminating this seemingly ubiquitous problem of agriculture over time.

The second reason growing exports will not solve all economic problems for all future farm generations is the potential unreclaimable deterioration of natural resources used in farming. The mining of our groundwater supplies in the gigantic Ogallala Aquifer has somewhat

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paralleled our growth in the exports through P.L. 480 and market forces over the last twenty-five years. Already the drawdown of the water table is causing some farmers to shift back to dryland farming methods. As groundwater withdrawals eventually drop to recharge levels and the irrigated area shrinks, we perhaps can claim that our former endowment of stock water resources was exported with the enhanced foreign sales of grain in the later decades of the twentieth century. The important point is: Export growth will not solve all adjustment and income problems of these farmers in the future.

Perhaps of more long-run importance to society is the level of exports which can be maintained and the set of technologies which can be used while productivity of U.S. agriculture is sustained in the long run. The major complex involved here is soil erosion and related environmental problems. Some agriculturists propose that we are exporting our top soil and future agricultural productivity along with the record amount of grain moving into international markets. Of course, many soil profiles are so deep that each ton of soil lost does not immediately lower productivity. Agronomists have estimated soil loss rates (t, or tolerance levels) which vary with soil type and climate and provide an approximation of the rate at which soil can be eroded before productivity declines become effective (Wishmeier and Smith).

There is considerable evidence that the interrelated forces of farm structure, enhanced exports, high commodity prices, and extremely inflating land values have encouraged a near-monoculture type of agriculture which is exploitative in nature and gives rise to high rates of soil erosion and related chemical runoff. Under present machine and crop technology systems, there is a strong pressure for farms to become large and highly specialized (hence, the increasing monocultural nature of farming). Becoming larger through land purchases is a popular way to increase wealth under inflating land values. Interest payments on borrowed funds lower income taxes and enhance current after-tax-income while generating long-term capital gains in land value appreciation. With mammoth capital outlays required for machinery and land purchases, plus the need for large and immediate cash flows to service interest and principal payments, many farmers are, as one of our farmer friends puts it, "forced to farm the land like hell." While present or potential productivity may be declining, the farmer can accumulate more land and gain automatically as long as land value inflation continues. A part of rapid land value inflation has been indirectly due to export volume in recent years. To an extent, investment in farm land becomes akin to investment in aged tenement buildings in larger cities; repair of depreciation can be foregone with financial advantage if real estate values maintain a satisfactory inflation pace.

There is considerable belief and some evidence that high exports and the associated high commodity prices and land inflation have accentuated soil erosion on many fragile soils of the nation. So great has this concern become that a number of public bodies and institutions have begun to delve into it. Included are the activities of the National Academy of Science (National Research Foundation), the Office of Technology Assessment, Resources for the Future, the Conservation Foundation, the North Central Regional Research Committee-III, the U.S. Department of Agriculture through its monitoring and analysis work of the Resources Conservation Act (RCA) and a consortium of Land Grant Universities, the U.S. Department of Agriculture, and most of the professional societies representing agriculture (Hauser). More empirical evidence needs to be gathered. However, there is growing quantitative evidence that soil loss rates have accelerated in the last decade, with the realized or potential twin effects of reducing land productivity and furthering nonpoint pollution of our streams.

While some progress has been made in conservation tillage methods and conventional conservation practices, there also has been an accentuated shift to crop specialization such as the corn-soybean patterns of the Corn Belt on both level and hilly land. These semimonocultures, another representation of farming structure as it moves to larger and more specialized farms, give rise to higher levels of soil erosion than did the meadows rotations and diversified farming systems of previous decades.

A larger acreage of row crop, the shift to a near-monoculture and the advent of huge tractor and machine units which cannot readily be used with terraces and contouring interact with the high commodity prices and land values which have been associated with growing exports over the last decade. Studies at different times in Western Iowa show a large

increase in soil loss (Blase and Timmons, Hauser, Larson). Timmons reports an increase of nearly 25% in erosion rates in Ida-Monona-Hamburg soils in Iowa in less than twenty years and projects large increases over the Corn Belt (Schuh, Timmons 1979a). Of course, the incorporation of set-aside land from the early 1970s, as exports exhausted surplus stocks and negated the need for grain supply controls, also has contributed to greater erosion. Typically, this was somewhat marginal land.

Tradeoffs between Export and Soil Loss Levels

Certainly at some high levels of sustained exports, in conjunction with certain technologies that might be used in agriculture, soil erosion and agricultural productivity must become important national problems. Extremely high export levels may be attained in the short run which cannot be maintained in the long run if agricultural productivity is to be maintained. A trade-off curve between export levels (in total production levels for domestic or export use) does exist according to a set of models which we have had operational over a number of years (Daines and Heady, English and Heady, Larson et al., Meister and Nicol, Nicol and Heady, Timmons 1979a). These models are now being used to help the U.S. Department of Agriculture in its RCA monitoring and analysis and for related research. Since these models are documented elsewhere, we will forego detail and summarize only their general characteristics. The models are national and interregional in nature with 105–223 producing regions and 25–35 market regions and a linking transportation submodel. Each producing region includes 5–9 separate land classes with differential erodability and soil loss. (Irrigated regions have 10–18 land classes to allow for both irrigated and dryland crop possibilities.) Soil loss coefficients are defined for each crop or crop rotation, each conservation practice (contour, terrace, strip crop, etc.) and each tillage method (conventional moldboard, no till, conservation till, etc.) on each land class in each producing region under the varying climatic conditions prevailing. Restraints at different levels thus can be placed on soil loss per year for each land class in each producing region, with export possibilities determined accordingly. (Erosion restraints also can be established for regions, watersheds, or other physiographic entities.) One restraint level of particular relevance is the "t" tolerance level, the level of soil loss which agronomists estimate can occur if soil productivity is to be maintained (Wade and Heady). Alternatively, exports can be parameterized or set at different levels while soil loss per acre is measured by land classes within regions, or by regions, watersheds, river basins, etc. When used with an objective function of least-cost or competitive equilibrium, the models show the combination of crops, conservation practices, and tillage methods (i.e., the technology set) which will maintain a given level of soil loss at minimum cost while allowing a given level of exports to be attained. (As a long-run competitive equilibrium model, it also can show the most efficient combination of technologies for a given soil loss and export combination.) We have been in the process of deriving these possibilities for the U.S. Department of Agriculture in its RCA analysis and now are extending, respecifying and updating models for the 1985 RCA evaluation. These models not only can indicate the various sets of exports and soil loss levels which will allow sustenance of agricultural productivity over the long run (or the level of soil loss conforming to a given export level or vice versa) but also can estimate the cost of abating soil loss to specified levels and various export levels. They also can provide the basis for estimating the redistribution of income and asset values, especially among regions, associated with any specified or policy-induced soil loss and export sets.

We have recently constructed a five-land class, 105 producing-region model to focus on the relationship between soil loss and export levels. The land base (table 1) consists of 403 million acres of cropland estimated available in 1977 from the National Resource Inventory (U.S. Department of Agriculture). We project 26 million acres will be converted to nonagricultural uses by 2000. All but approximately 24 million acres would be available for the endogenous crops. The land classes are selected so that a range of erosion hazards and farming practices can be represented in the model with prime agricultural lands included in land classes 1 and 2, erosive but otherwise suitable lands in land classes 3 and 4 and most marginal lands incorporated in land class 5.

The range, pasture, forest, and other lands with high and moderate potential for conversion to cropland is incorporated in the model

Table 1. Projected 2000 Crop Land Base

	Region							
Item	North Atlantic	South Atlantic	North Central	Great Plains	South Central	North-west	South-west	Total
	(1,000 acres)							
Endogenous cropland:								
Land class 1	1,613	6,459	32,831	7,963	7,421	1,090	2,372	59,749
Land class 2	6,764	27,775	81,444	31,830	30,333	5,253	3,652	187,052
Land class 3	1,879	3,463	16,773	25,939	15,292	6,088	795	70,228
Land class 4	694	1,177	4,846	9,361	5,213	2,138	1,192	24,620
Land class 5	431	1,118	2,939	4,015	1,808	796	423	11,530
Total	11,380	39,993	138,834	79,108	60,067	15,364	8,434	353,180
High potential land:								
Land class 1	56	597	572	245	528	21	12	2,031
Land class 2	705	8,756	5,577	3,071	4,342	604	472	23,527
Land class 3	112	1,074	1,462	2,553	1,969	309	99	7,578
Land class 4	45	227	370	728	209	103	89	1,771
Land class 5	81	298	180	551	171	397	1,108	2,696
Total	999	10,952	8,161	7,148	7,219	1,434	1,690	37,603
Moderate potential land:								
Land class 1	94	360	360	132	316	5	8	1,269
Land class 2	2,214	14,963	8,989	5,006	8,375	993	1,155	41,695
Land class 3	736	4,517	3,770	7,144	7,423	649	363	24,602
Land class 4	308	1,748	1,794	3,536	2,486	543	717	11,132
Land class 5	500	2,281	1,212	3,548	1,109	968	1,781	11,399
Total	3,852	23,869	16,125	19,366	19,703	3,158	4,024	90,097

with appropriate conversion costs. Some authors (Amos and Timmons, Shulstad and May) have questioned whether as much as 127.7 million acres could actually be converted to cropland under any set of realistic conditions so we have duplicated our analysis with high potential land only and with both high and moderate potential land available for conversion. Except where noted otherwise below very similar patterns are evident in the results for both scenarios.

We project domestic consumption of endogenous crops in 2000 to be as follows: 199.1 million tons of feed grains (corn, sorghum, barley, and oats); 1,033 million bushels of wheat; 2,293 million bushels of soybeans; 7.7 million bales of cotton; 57.4 and 82.1 million tons of nonlegume and legume hay, respectively (from cropland only); and 109.4 million tons of silage. Projections of domestic consumption levels are relatively reliable so no attempt was made to parametize these numbers. Domestic demands do not include a component of grain for gasohol production nor is a biomass crop implicit in the land base. The overall effect of a significant "energy from agriculture" program would be similar in effect to increased exports but differ in detail.

Four different export levels in the year 2000 are examined. The lowest export level (level I) is a 50%, 53%, and 75% increase over historical exports over the period 1977–79 for feed grains, wheat, and soybeans, respectively. Export levels II, III, and IV are a 17, 67, and 117% increase, respectively, over the base export level. The most recently available NIRAP projection falls between export levels II and III. All export levels are feasible when both high and moderate potential land is available for conversion to cropland, but export level IV is not a feasible level when only high potential land is available for conversion.

An important result of our model is that far more extensive use is made of soil-conserving tillage methods and conservation practices than are currently practiced. No-till is practiced on between 50% and 60% of the land in all solutions and conservation till used on most of the remaining land. We feel that there are inherent advantages in the conservation till and no-till practices developed and being developed to make these the standard tillage methods of the future. Approximately 70% of the cropland is also selected for some conservation practice. Contour plowing is the most important, accounting for 50%–55% of total cropland. Strip cropping is relatively insignificant, accounting for around 4% in nearly all solutions. Terracing is used on 10% to 15% of the cropland with the amount of terracing increasing with exports.

Despite the extensive adoption of soil-con-

serving tillage methods and conservation practices, the tolerance levels for gross soil loss are exceeded on one or more land classes in a large portion of the producing regions even with low export levels. Tolerance levels are exceeded on some land classes throughout most of the North Atlantic and South Atlantic zones, a large portion of the north central and eastern part of the South Central and Great Plains zones. Tolerance levels also are exceeded in some of the most important agricultural areas in the Western states. The most notable change with increased exports is in the mid-continental states where tolerance levels are exceeded in a large number of producing regions only with highest export levels, although more marginal land is brought into production in all regions.

At low levels of export demand most of land class 5 is not used. Practices adopted on land classes 3 and 4 contribute most heavily to erosion. When export levels increase it becomes profitable to adopt practices which conserve soil and productivity on land classes 3 and 4: Soil loss per acre drops sharply for these land classes in many producing regions. The most marginal cropland in the existing land base, land class 5, is brought into use greatly exceeding the tolerance levels. The distribution of gross soil loss from cropland is very skewed in all solutions and becomes more skewed with increased exports. The number of acres in absolute terms exceeding the tolerance levels is not great in any solution and decreases with increased exports nationally and in all regions except for the South Atlantic, Northwest, and Southwest.

Conversion of potential cropland to cropland increases with each increase in the level of exports. Potential cropland is available in nearly all land classes in most producing regions, but the distribution of potential cropland is more skewed towards the erosive land classes. The land that is converted at lower levels of exports tends to be the least erosive. As export levels increase a larger proportion of the conversion is for land classes 3–5.

Gross soil loss increases with exports, but not dramatically at the national level. For example, gross soil loss increases by 21% when exports nearly double in moving from export level II to IV for the scenario with both high and moderate potential land available (table 2). With only high potential land available, soil loss decreases with increases in exports until the highest attainable levels of exports are reached where soil loss shoots up rapidly. Comparing the lowest level of exports with the highest, 1.88 and 0.24 tons of soil loss is incurred for each $100 (at constant prices) of increased exports for the scenario with high and moderate potential land conversion and the scenario with only high potential low conversion, respectively. But the trade-off at the national level conceals some of the most disturbing results. Soil loss in the western two zones more than doubles. There is a very large increase in soil loss both in absolute and in relative terms in the South Atlantic zone where soil profiles are relatively shallow and a high proportion of eroded soil finds its way into water courses and rivers.

Policy Implications and Focus

We expect to be able to provide increasingly refined quantitative estimates of the trade-offs or possibility frontier between exports, soil loss, and productivity coefficients before the

Table 2. Gross Soil Loss

	Zone							
Demand Levels	North Atlantic	South Atlantic	North Central	Great Plains	South Central	North-west	South-west	Total
	(million tons)							
Full land availability and moderate yields:								
II	24,468	162,769	299,648	234,507	205,554	21,829	12,043	960,819
III	30,093	198,124	284,156	260,169	215,795	29,665	15,743	1,033,745
IV	26,053	251,577	319,100	282,892	221,783	55,480	39,294	1,196,179
High potential land and moderate yields:								
I	23,108	155,189	329,298	212,434	178,281	19,768	11,342	929,420
II	24,644	180,476	259,316	230,541	171,072	27,488	12,271	905,811
III	18,254	210,508	265,008	208,278	180,578	45,640	16,269	944,534

1985 RCA assessment. However, we believe that those already generated provide a relevant basis for policy based on these normative estimates which indicate future potential. Some policy directions become fairly obvious. Society could, of course, decide to "continue all-out export efforts while domestic productivity goes down the tube." We doubt, however, that society should or will do so over the long run.

If society selects a mix of exports, technologies, and soil losses which maintain agricultural productivity and a favorable environment, it could use several approaches. One would be to attempt to set export limits (quotas, embargo limits, etc.) at levels which are consistent with a soil loss level, under appropriate technology, which maintains soil erosion and agricultural productivity at the desired level. For example, a dictum could be announced that exports above some level are to be embargoed. But a policy of this sort would be clumsy to administer (and could imply a farm income maintenance program due to reduced commodity prices). Exports also could be taxed for similar purposes. An upper limit or tax on exports also would be difficult to implement with respect to the most erosive soils. For example, highly erosive lands near the point of export might be planted to corn, soybeans, cotton, and similar row crops while level lands elsewhere were planted to close-grown crops and forages. Export controls would in no way relate to or restrain the type of conservation practices, tillage methods, or other technologies which relate to erosion and chemical run-off and, as our results indicate, would likely not be fully effective in protecting agricultural productivity. Hence, rather than to use export levels as a means to direct land use and erosion control or environmentally related technologies, the causal direction might best be in the opposite direction.

Supposing that there is some combination of quantitatively optimal levels of exports and soil conservation technology, then the cost (i.e., opportunity cost) of not controlling erosion should be sufficiently high that it eventually limits production and export levels—supposedly through a set of price mechanisms which encourage soil-conserving land use and technologies and thus increases commodity prices to the needed level in limiting exports to maintain long-run agricultural productivity. The prices (subsidies or taxes) could be related to specific conservation practices, tillage methods, and land use technologies which do restrain erosion (and perhaps chemical run-off) to goal levels. To tie the price (i.e., tax or subsidy) of erosion control to the particular practice and land class would be most practical in implementation and in getting erosion control where it is most needed in terms of (*a*) rates of soil erosion, and (*b*) the productivity of the land classes and locations to be conserved (Daines and Heady). One variant of this approach would be to institute an export "check-off" to fund such a program, perhaps adding to the rationale and political appeal.

Numerous other policy means could be used to attain sets of export and soil loss rates which would conform with a socially determined goal or optimum. Conforming soil loss levels (such as tons per annum, *t*-levels, etc.) could be established, then farmers could be penalized (fined, jailed, taxed, etc.) for soil losses above these levels. Policy of this nature is attractive from two perspectives: effective agricultural productivity is most genuinely protected; large reductions in soil loss would result (recall the skewed distribution of soil loss) and thus a substantial enhancement of environmental quality. However, this instrument would have low political acceptance and would entail other implementation complexities.

Drawing production and export levels down to conform with maintenance of long-run agricultural productivity (or the level which is determined to be socially and economically optimal via appropriate intergeneration expression of time preference or other criteria) would be expected to increase total market value of sales, and likely net income of farming, since most price elasticities of demand are less than unity. This growth in income through the market per se would be unlikely to result in an equitable redistribution of farming returns. Farmers on level land would have no conservation investment and could even cultivate their land more intensely; farmers on erosive soils could be faced with both greater investments in appropriate machinery and land preparation and reduced output from a less intensive agriculture. A system of practice subsidies or incentives (i.e., cost sharing, cross-compliance, etc.) would be needed to restore equity, as well as attain conservation goals, if unanimous consent were approached in the optimum mix of exports and soil erosion abatement.

Institutional and Other Forces Apart from Markets

The enhancement of markets through exports, coupled with inflation as summarized earlier, can have important impacts on land use and potential land productivity. Not every land class in each location is faced with an immediate precipice of yield declines. Erosion can proceed for some time in areas of deep soils before productivity declines will be experienced or will not be offset by advanced technologies. While they are greatly improving knowledge, agronomists are not in complete certainty and agreement on the rate of soil formation, vis-à-vis, rates of erosion or land deterioration. But a policy based on "t"-values may be desired until greater certainty in knowledge is attained. It would seem unwise for a society to let a major portion of its land erode down to the last two inches of soil useful in productivity. It thus is important that policies with respect to exports be integrated with those in respect to soil erosion, resource conservation, and environmental considerations.

In making this statement, we are, of course, aware that it is not alone the thrust of market forces and prices which cause exploitation of agricultural resources. Favorable price prospects over time can even place a premium on resource conservation and investment in it for some land resource groups. Frequently, it is not markets and prices per se which cause an accelerated use of stock resources such as groundwater or an exploitive use of land. The institutions and related conditions prevailing in agriculture and surrounding the market can do so. Examples include tenure systems and uncertainty of tenants' returns from conservation investment over time, the supply, terms and repayment schedule of credit, the age and immediate planning horizon of the farm operator or land owner, the paucity of information available to farmers, and others. There also are cases in which profitable conservation practices are not used because the farm operator or land owner is unaware of the level of return. In other cases, conservation practices are adopted with a distributed lag because farmers contrast them to customary practices (e.g., clean-plowed fields with no trash compared to residue-covered land). Where these voids exist, when conservation practices otherwise would be economic to the individual society, appropriate policy means or institutional change is needed to eliminate them.

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Toward a U.S. Agricultural Export Policy for the 1980s: Discussion

Eric Monke

Sarris and Schmitz suggest that increases in exports are not likely to benefit U.S. agriculture, and that "production may have to be curtailed—at least in the short run—for optimal pricing to be achieved . . . ." Their argument has three principal components. First, agricultural growth is likely to depend heavily on research and development, and further expenditures in this area are asserted to have a deleterious impact on producer incomes. Second, U.S. agricultural trade is dominated by cartels, and increased production leads only to increased purchasing power for importing nations. Finally, increased participation in world markets creates increased price instability, and further reduces producer welfare. This discussion argues that none of the authors' conclusions in these areas are justified, and that continued growth in exports is likely to offer substantial benefits for the U.S. agricultural sector.

Research and development (R&D) expenditures are asserted to have a deleterious impact on producer incomes if such expenditures cause the supply curve to shift outward and become more elastic in the face of a fixed world demand schedule. Even if these supply-demand conditions were accurate, the conclusion suffers from a myopic view of the impact of R&D expenditure. Technological change frees resources to produce goods in other sectors of the economy, and can thus be regarded as a complement to capital accumulation in the process of economic growth. Indeed, some authors suggest that R&D is no more than a special form of capital accumulation (Jorgensen and Griliches). The key point is that the induced shifts in the industry supply curve give no indication of the changes in returns to individual factors of production. The reason is that technological change implies new input combinations, and declines in total industry revenues do not necessarily imply declines in the returns to individual factors or to the total factors employed in an industry. Admittedly, technical change can cause difficulties. Unemployment may result if aggregate demand is not increasing, and adjustment difficulties occur for resources committed to now inefficient technologies. These problems are short run rather than chronic in nature, however, and do not require an economy to restrain R&D and forego the benefits of economic growth.

Market power of importers is a second reason for U.S. policy makers to avoid expansion of U.S. exports. Tariff policies, implemented in wheat importing countries, for example, are asserted to benefit importers because "(domestic) producer gains plus the tariff revenue more than offset the consumption losses" of a tariff. Such evidence cannot justify the above conclusion. Tariff revenues are intracountry transfers from consumers to the government, and welfare increases from such transfers are dependent on empirically undefinable social welfare functions. The gains of domestic wheat producers are not gains at all when viewed in a general equilibrium context, as wheat tariffs attract resources which were more profitable when world prices prevailed for all commodities. When a country cannot influence world terms of trade, production income is maximized at world prices and can only decrease when resources are diverted into different production activities via tariffs.

Increases in importing country welfare thus depend on the ability to influence the terms of trade with the U.S. and other exporters. Since each importing country buys only a small share of world imports, establishment of the optimum tariff (the reciprocal of the price elasticity of export supply) requires a cartel in which individual country objectives are subjugated to group cooperation. Grains would appear as one of the least attractive commodities

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for such an arrangement. The importance of imports in domestic food policies of many developing countries and the diverse set of countries involved in grain importation renders implausible the prospect of collusive action. Furthermore, it has not yet been shown that world prices of any principal export products are lower under current conditions than under free trade. In the case of rice, for example, the prevalence of government policies which tax domestic production and subsidize domestic consumption suggest an excessive reliance on world markets, and world prices which are higher than their free-trade levels (Falcon and Monke).

A third concern of Sarris and Schmitz is that increased exports will lead to price instability. In lieu of empirical evidence, a supply-demand model is developed and parameter values are hypothesized to support their conclusion. The first hypothesis is that the price elasticity of developing country demand is almost equal to that of U.S. domestic demand ($\gamma/B \simeq 1$). At the consumer level, this hypothesis is totally implausible because of the difference in income levels and the importance of processing costs in U.S. food grain consumption. Even if government intervention on behalf of developing country consumers reduced foreign demand elasticities, such values could still be much larger than U.S. consumer demand elasticities. The second hypothesis is that world export demand fluctuates more than domestic supply, so that $\sigma_u/\sigma_w < 1$. But, given the role of weather in output variation, the reverse result seems more plausible. Because weather varies among geographic regions at any given time, variability should decrease as geographical area expands ($\sigma_u/\sigma_w > 1$). Table 3 of the Sarris-Schmitz paper shows that for larger values of γ/β or σ_u/σ_w, price stability is increased by a reliance on world markets.

Even if increases in the relative importance of exports did lead to increased price instability, it does not follow that U.S. producer welfare is diminished. Empirical evidence (Falcon and Monke, Peck and Gray) suggests grain exporters may gain from price instability, since the export demand curve appears inelastic with respect to price increases and elastic with respect to price decreases. Government intervention on behalf of domestic consumers in developing countries and quota or variable levy policies in many developed countries create conditions whereby consumer demand is insensitive to world price changes. Elastic response to price declines may be caused partly by the emergence of additional end uses, such as animal feeds. Probably more important, however, is the behavior of commodity inventories. Peck and Gray's analysis of the demand for U.S. wheat inventories suggests a demand for grain which becomes almost infinitely elastic once the margin between current and futures prices reaches a certain magnitude. Part of the reason for the willingness of the market to encourage stock accumulation may be that yields are negatively skewed rather than normally distributed about their mean level. This phenomenon implies that production shortfalls and high price regimes are more probable than production surpluses and low prices.

Finally, Sarris and Schmitz suggest that the growth in world demand for grains is likely to slow or stop altogether, due to limited purchasing power in developing countries and the "rising agricultural protectionism in the major developed importing countries." If world demand is truly fixed, efforts to expand U.S. exports will clearly diminish world prices. There are a number of reasons to doubt such a stagnation in export demand and prices. First, even if per capita developing country incomes do not change, aggregate national income will increase because of population growth. Furthermore, positive rates of per capita income growth appear likely in at least some developing countries, such as OPEC and China. This small group comprises one-third of the population of the developing world. Potential demand increases also appear likely in the USSR and the Eastern Bloc countries, where ration programs have constrained meat consumption at levels well below those which prevail in other countries with similar incomes. The FAO projections cited by Sarris and Schmitz suggest a major decline in import demand from these regions over the 1975–85 period. On the basis of current trends, these projections appear erroneous. Finally, the author's evidence for increased agricultural protectionism among the developed countries consists solely of observed increases in ad valorem tariff equivalents in the EEC. These increases, however, are the result of falling world prices rather than changes in EEC prices and thus do not imply a negative impact on U.S. export demand. In sum, the potential sources of increased demand appear numerous enough to warrant at least a dose of the "unfettered optimism" so disdained by Sarris and Schmitz.

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Interrelationship among Export Markets, Resource Conservation, and Agricultural Productivity: Discussion

Herbert H. Stoevener

The main body of the paper by Heady and Short consists of a brief description of the models and their application to deriving trade-offs between agricultural output (export levels) and soil losses. These models are based on the ones developed at Iowa State University over many years. It is impossible for the authors to describe these models in detail for us during this discussion. The basic model used in this application consists of 105 producing regions and contains at least 5 land classes in each region. Soil loss coefficients are specified for each crop or crop rotation, each conservation practice and tillage method, for each land class in each region, apparently taking varying climatic conditions into account as well. From such a model a large number of variables can be analyzed with a good deal of specificity depending on the chosen objective function and constraints set.

Four different export levels are assumed for the year 2000, with no provision for gasohol production in domestic demand. I could not follow the description of these demand scenarios from the copy of the manuscript available to me. Apparently these projections fall on both sides of another recent independently derived projection of export demands.

I found the reported results interesting and instructive. They are not always what I would have expected. With increased export demands, the application of conservation practices is predicted to increase sharply, even on land which is already in production. This is inconsistent with the expectation of many that farmers are led "to farm the land like hell."

In spite of the widespread adoption of conservation practices, tolerance levels for gross soil loss are exceeded in a large portion of the producing regions even at low export levels. And, while gross soil loss increases with exports, though not dramatically, at the national level, the "number of acres in absolute terms exceeding the tolerance levels is not great in any solution and decreases with increased exports nationally and in all regions except" four (p. 12).

Anyone thinking about these results for a moment can easily develop a rationale why they may have been obtained. It is about this aspect of the paper that I would have liked to have seen a bit more detail. The authors will know from the experimentation with their models to what relationships these important results were most sensitive. A discussion of the results in the light of this information would have been very useful, especially from a policy standpoint. More information is necessary to understand the projected increase in conservation practices. What is it that triggers a change from the current status? It is the strength of these very specific models to be capable of providing these kinds of insights.

Similarly, there appears to be a great difference in resulting levels of soil erosion by regions as exports increase. Again, it would be instructive to know what accounts for these. Is it the physical characteristics outside the flattest part of the Corn Belt which do not tolerate any significant increase in crop production without major soil losses? Or is it the nature of export demands with higher export product prices caused by transportation cost differentials which exacerbate farming system changes in hilly regions closer to major seaports?

The Iowa State-developed models are part of the major inputs which the agricultural economics profession is making to the public debate on conservation policy. The models are sufficiently complex that it is difficult for any outsider to undertake their empirical evaluation. Perhaps this suggests that when presen-

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tations like this one are made to professional audiences, somewhat greater emphasis should be given to the analytical procedures when discussing the results obtained.

There is, of course, a limit on how much material can be presented in a conference paper of this type. But given my preferences, much of what was presented in the introduction (first six pages) could have been deleted. Many of the issues raised are common knowledge. The authors mentioned the implications for future farmer welfare of having a long string of growing future incomes already capitalized into land values. They mention inflationary expectations. For purposes of export and conservation policy it would be important to know which components of the returns to land ownership are due to agricultural use and which stem from inflation. However, this is a thorny issue. It is being addressed in a forthcoming paper by Castle and Hoch.

As far as conservation policy is concerned, Heady and Short appear to opt for a system of subsidies or taxes related to specific conservation practices, perhaps combined with an export "check-off" system to fund a subsidy scheme. Many of us, having studied this subject much less than the authors, would also find this proposal attractive. Again, it would have been nice if the authors had related this and the remaining policy discussion more closely to the analytical work. As I read the paper for the third time, I was struck by the lack of strong connections between the policy issues raised in the introductory pages, the final policy section, and the empirical analysis. The latter appears to be a much richer source for drawing out policy implications than was utilized in this paper.

I would like to make one final point about the general discussion of agricultural export policy which was touched upon in the paper by Sarris and Schmitz. Many of us in the agricultural community point with pride to the accomplishments of this sector in allowing for the large increase in exports that we have witnessed. One should recognize, however, that this is not a unique phenomenon in the national and international economy. While U.S. agricultural exports have risen rapidly (from 11.4% of farm cash receipts in the 1950s to 29.1% in 1980), their proportion of all U.S. exports has remained relatively constant during the post-war period and is considerably less than it was during the 1930s (CEA, p. 117). Exports as a percentage of gross national product (GNP) fell generally into the 4%–6% range. This changed during the early 1970s. In 1979 exports comprised nearly 11% of GNP (CEA, p. 203). Furthermore, on a global scale growth rates in agricultural trade have outpaced growth rates in agricultural productivity roughly by a factor of two between 1950 and 1980 (USDA, p. 4). When raising policy issues about U.S. agricultural exports, it is important to keep in mind that the subject of our concern is only one aspect of a growing internationalization of our production and consumption systems.

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Changing Delivery Systems for Agricultural Extension
(John E. Ikerd, Oklahoma State University, Presiding)

Extension Program Delivery—Past, Present, and Future: An Overview

R. J. Hildreth and Walter J. Armbruster

The 1914 Smith-Lever Act, which launched extension education, has been amended frequently and was rewritten in 1953. However, its statement of basic purpose has remained the same: "to aid the diffusion among the people of the United States useful and practical information on the subjects relating to agricultural and home economics and to encourage the application of the same." An underlying though unstated purpose of this diffusion of information was to help bring about changes in behavior and in the economic and social environment designed to promote well-being. In other words, the extension purpose is to foster change in society—i.e., change by individuals, households, firms, and governments.

Development of Extension Delivery Methods

The land grant university and the extension service were distinctive American inventions (Chin and Benne). Extension was launched to deliver new applied knowledge to farm and rural people in the United States and to transmit their interests to the land grant university research community. That linkage continues to be the role of extension education, though significant changes in the audiences and environment in which extension operates continue.

The extension delivery methods adopted following the passage of the Smith-Lever Act relied on an approach whereby the learner observes a demonstration or tries out an activity. According to Baker, the demonstration form of education was developed by Dr. Seaman A. Knapp of the U.S. Department of Agriculture (USDA) Bureau of Plant Industry, who established the first farm demonstration at Terrell, Texas, in 1903. Knapp believed that though farmers would not apply methods successfully used in research, they would readily follow successful operations of a neighboring farm. Other demonstration programs were developed in Texas, Louisiana, and Arkansas in the early 1900s. The first county agent position was established in Smith Co., Texas, in 1906. Simultaneously, the northern states instituted county demonstration work based on farm management surveys to discover the practices of successful farmers. While Knapp distrusted college professors, the northern states' county demonstration agents were mostly college trained and worked in close cooperation with the state colleges and farm organizations.

Thus, while different philosophies about extension program delivery methods existed even before the passage of the Smith-Lever Act, the demonstration approach was widely adopted. It did not have a systematic teaching focus, but rather one of learning by the farmer observing a situation similar to his own.

Extension Delivery Today

In its early history, cooperative extension's role appeared straightforward and limited. Extension was the organization best equipped to attack informal educational problems of production agriculture and rural living. There was a close interrelationship of farmers and rural residents with extension.

Changing Extension Role in Traditional Areas

Since the introduction of extension, there have been dramatic changes in agricultural production, agricultural marketing, and the rural communities which extension serves.

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Concurrent with increasing productivity, structural changes throughout the farm production, food processing, and marketing system have changed the role of extension in farmers' production and marketing decisions.

Production supply firms and agricultural cooperatives provide field men who help farmers with technical information that in earlier days had come primarily or exclusively through extension agents from land grant university research findings. An increasing number of agricultural consultants provide similar services. The input supply companies have done additional research, often drawing upon the basic research done at the university. They develop new products and are in the forefront of knowledge about actual farm application. While this has not completely eliminated the role of county agents, it has certainly supplemented and partially replaced them.

As the agricultural marketing system evolved over time, most central wholesale markets which received products shipped from long distances have been replaced. Now chain store buyers and food-processing firms have buying representatives dealing directly with farmers, feedlots, etc., or buying through local country auctions. An increasing contact between representatives of the purchasing entity and the producers is the result. Thus, the role of extension marketing has shifted more to helping farmers develop overall marketing strategies and providing educational programs related to marketing institutions and policy. That activity has become much more important in recent years with changes in government programs and the opening up of world trade in major commodities, with consequent fluctuation in prices.

New Subject Matter and Clientele

Hildreth has pointed out some of the changes faced by extension in recent years. Extension is no longer confined to agriculture and rural life. Expertise to deal effectively with the problems incurred in the new areas is not always available on the campuses of land grant universities and demands a multicollege approach and cooperation with off-campus resources. Extension is not the sole provider of educational programs in the new fields, and in some, may be a relatively minor participant, e.g., urban youth and community resource development activities.

Serving the new areas and audiences has created stresses on extension. First, sufficiently increased resources have often not accompanied the new demands. Shifting resources from established programs has been painful to many of extension's traditional clients who jealously guard "their" programs. Second, the diversity of the clients for traditional programs has increased a great deal. Hobby farmers, part-time farmers, small farmers, subsistence farmers, and commercial farmers may all need farm management programs—but of varying characteristics. Third, delivery mechanisms such as meetings and publications are less useful for the new audiences which include persons with low education and income levels, just as they were not useful when most farmers had low education and income. And competing time demands, more glamorous delivery mechanisms, and audience heterogeneity make them less effective. Fourth, topics for educational programs that were once innocuous may now be quite controversial. For example, the use of insecticides as a means of increasing productivity may be questioned by organic gardeners and farmers or a policy to increase farm income may be questioned by consumer groups.

Changing Delivery Methods

While the major principles of extension programming—involving students in program development, presenting education in an informal setting, and focusing on practical information—remain the same, some new delivery techniques have developed.

For example, a variety of communications devices are being used. Telephone messages accessed by toll-free telephone lines provide cost-effective delivery for relatively simple practices. And there is growing use of computers, video tapes, and electronic networks, some interactive.

Some very productive delivery methods have evolved using salaried aides and volunteer agents. Salaried aides from the local community have been successfully used to deliver nutrition education to low income families and small farm programs. The idea of volunteer leaders developed in 4-H programs has been applied in using master gardeners to deliver information about gardening, primarily to urban audiences. These lower paid personnel, locally based to reduce travel costs, greatly expand extension's delivery capability for the same budget.

The identification and education of community leaders is used widely in community resource development extension programs. The pilot leadership development programs supported by the Kellogg Foundation have demonstrated their worth and are spreading among the states. Extension Homemakers organized at national, state, and county levels provide leadership development. A Kellogg funded program is currently developing public policy education program delivery capability through Extension Homemakers in the western states. The 4-H and Homemakers organizations, sponsored by the Cooperative Extension Service, develop leadership through volunteer educational and service projects benefiting the members and community. These volunteer programs expand extension's delivery capability without the direct cost of funding salaries for program delivery.

Another set of organizations which enhance program delivery capability are farm management associations employing paid field staff to deliver farm management programs.

Effectiveness of Extension

Given the changes and pressures, it is appropriate to look at what evidence exists about the value of extension in meeting the needs of today's society. If value can be measured in terms of the effect of extension on agricultural productivity, there are several recent economic studies that may shed some light. Generally these studies combine research and extension, and have found that the USDA and land grant university research and extension efforts have made a major contribution to the rate of technical change in agriculture.

Most studies place the internal rate of return in the United States between 25% and 50% to investments in research and education (Sim and Gardner). Araji estimated the internal rates of return for research investment in the western region related to selected commodities. His analysis identified over 50% of the results as being associated with input from extension. Peterson and Hayami suggest that the public investments in research and extension are responsible for as much growth in American agriculture as are changes in the quality of inputs and economies of scale in farm production. The 1980 evaluation of extension cites Evenson's statement that the public sector of agricultural research and extension and the level of education of farmers together may account for nearly 50% of agricultural productivity increase between 1948 and 1979 (USDA). Huffman recently estimated productivity differences on black and white operator farms in four southern states from 1964 data, when two separate extension services existed. He concluded that much of the lower productivity for black farmers was explained by the lower level of schooling and extension education available to them compared to white farmers.

So, if the methodological approaches of the studies cited are accepted, a minimum conclusion is that there is a positive, relatively high rate of return to society's investment in research and extension dealing with agricultural production and marketing. The studies cited above suggest that extension education is a good investment, but they do not give much insight into the possibilities for improving the value of extension through changes in program delivery.

Extension Delivery Tomorrow

What needs to be taken into account in thinking about assuring meaningful extension delivery for the future? And what changes are needed to keep extension delivery viable, efficient, and progressive? These are difficult but important questions which are only introduced in the following sections.

Implications of the Changing Farm Typology

The best known characteristics of the farm sector are that the average farm size has increased and the total number of farms has declined. An ESCS study projects that by the year 2000 farms probably will be arranged in a bimodal distribution with a large proportion of small farms, ever increasing proportion of large farms, and a declining proportion of medium size farms (Lin, Koffman and Penn). The implications for extension programs of this bimodal distribution are very significant. The traditional audience for extension programming comes from the middle size farmers who are not so large that they use direct access to researchers to obtain information. Extension has had a difficult time directly reaching the small and part-time farmers, the most numerous category.

The phenomenon of the large or knowledgeable farmers obtaining information directly

from experiment stations and other scientific sources rather than from county extension agents is described by Havelock and Benne as "by-pass." Extension must either better prepare itself to deal on a timely and informative basis with the large or knowledgeable producers or recognize that theirs is a minor role with that segment of agricultural producers and concentrate on the remaining segments of the producers.

The latter option is embraced by the recent ESCOP report which proposed as a strategy for public research and extension: Scale neutral research and extension should be emphasized; special measures should be developed to help the moderate size farm through programs dealing with financial, marketing, and production management; and an overall package of assistance, especially in dealing with problems of poverty and underemployment, should be provided to assist those associated with small farms.

Improving Extension Delivery Efficiency

Adjustments will be necessary to maintain a clientele among farmers. But other changes also are called for if extension is to weather the increasing demands for accountability. Boone, Dolan, and Shearon argue that funding for educational programs is positively related to demonstrated efficiency and effectiveness. Rather than follow the same objectives and methods year after year, extension must build in system renewal processes to remain a viable educational force.

Extension is facing increasing demands for improved efficiency of program delivery from both the input and output sides of the extension production function. Increasing amounts of knowledge to be extended, transportation costs and personnel costs are forces from the input side. The growing complexity of decision making in agriculture, the growing specialization of agriculture, and policy development are forces from the output side.

Siegfried and Fels, reviewing research in teaching college economics, report that programmed instruction can accomplish economics learning in a shorter length of time, and self-pacing of learning has a significant contribution to make to economics education. While the results above are for the classroom, programmed instruction and self-pacing of learning may work better for extension programs with more highly motivated participants than for classroom students.

This brief analysis leads to consideration of certain alternatives for the improvement of extension programming efficiency. The selection of audiences with higher human capital for a given extension program could lead to efficiency gains. This could be accomplished by better targeting programs to specific clientele groups that would consist of individuals with a better knowledge background at the start. The use of extension teachers with higher human capital could also lead to efficiency gains. This can be achieved through increased training of field staff or the use of more specialists, a point to be discussed later. There are a number of opportunities to improve utilization rates of both faculty and clients. These run a gambit including group meetings as opposed to individual consultations, use of mass media, and electronic transmission of information.

Increasing Extension Specialization

The changing clientele for extension and the increasingly technical knowledge to be delivered to them may call for more specialization. But the likelihood of significant expansion of state specialist ranks is slim. However, there are other ways of developing specialists that may be cost efficient for the extension system.

The development of national or regional specialists offers some potential. The rural crime center at Ohio State is essentially serving the role of a U.S. specialist. Several proposals have been brought forward in the past couple of years for development of a regional or national specialist in transportation economics. The Western Livestock Marketing Project performs a specialist function for the entire western United States, with some spillover into other regions.

The many issues and concerns which cross state and even regional boundaries argue for additional regional or national specialists. Developing programs using regional specialists would enhance the work in computer applications to farm management and marketing and using computer networks as transmitters of timely information. The recent work in electronic marketing has the potential to go well beyond state boundaries in some cases. Joint funding of such regional or national specialists would be a much more efficient delivery method than having personnel who are not familiar with the topic attempting to deliver educational programs related to it.

Another way of achieving cost efficient

specialization might be to have local or area agents who have particular interest and expertise act as a state or even regional specialist. This may become more feasible as more highly trained individuals are available in county and area slots.

Electronic Program Delivery

The use of computers and electronic networks is growing in farm management and marketing programs. The technology has also been applied in CRD and public policy programs and its use will likely grow in these programs.

To realize the full potential of computers and electronic networks hardware, software must be developed and local agents trained. Cooperation among states in developing software is growing, but more is needed. Local agents can increase their output and educational capabilities by using this technology. Thus, training and involvement of agents by specialists will be productive as the use of the technology grows.

The technology creates ability to transmit large amounts of information and provide the opportunity for individual decision analysis, both exciting prospects. However, there is danger that both the client and extension worker will overlook the use of the technology to provide learning situations. Extension cannot, nor should it seek to, maintain a monopoly on electronic delivery of information and individual decision analysis services. Extension must provide educational opportunities utilizing electronic delivery to allow its clientele to better utilize the information and analysis capacity of computers and electronic networks.

Implications for Extension Economists

The above discussion leads to some speculation about the implications for agricultural economists conducting extension education programs in coming years. Decisions and events off the farm may be more important than decisions and events on the farm in terms of their impact on the well-being of farmers and consumers. Public policy and community resource development are not only important for main street businesses, consumers, and rural residents, but also for farmers (Wise). ment and delivery for the wide range of students who want and need their educational services?

Agricultural economists have a role to play not only in the production and marketing of food and agricultural products but also in activities related to concerns about food and agricultural policy, community development, rural government finance, conservation, environmental and water policy, transportation, etc. It will be important for extension programs developed by agricultural economists to focus ahead to anticipate expected changes in the composition and structure of the agricultural production sector, the agricultural marketing sector, consumer interests, and concerns of rural communities, community leaders, and other institutions dealing with food, agricultural, and rural communities.

Extension is a link between research and the users of knowledge. Traffic flows both ways over the linkage. The extension professional thus needs to be able to adapt the new knowledge developed by research to the educational needs of the user, as well as communicate the needs of the user for new knowledge to the researcher. The scholarship requirements to achieve these tasks are large. The extension professional often needs to be able to touch the abstract and the concrete in the same flight of thought. In many ways, more scholarship is required here than is required to develop new knowledge. The economist working in extension cannot be divorced from new developments in economics any more than from new developments in farming, marketing, or public policy. The extension professional must take an active role in the AAEA, just as he must maintain his contacts with the managers of the firms or organizations who constitute his students.

The challenges presented to extension by changing clientele, program needs, and delivery innovations must be dealt with in a mode of increasing efficiency. Creativity and imagination are needed to be an economist filling the role of an agent of change through extension education where the needs will continue growing faster than funds.

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delivery system. With the backup of state specialists, the county agent can meet the educational needs of the small- and medium-size farmers. Demonstrations, short courses, tours, and publications remain as effective means for delivering information to these audiences.

If resources were more abundant, area specialists would be the preferred means of delivering educational programs to commercial farmers. But the harsh reality is that extension will have to operate with less. Frequently, the county agent will have to be the primary local contact for commercial farmers.

The new developments in electronic communication, individualized learning, data storage, retrieval, and analysis offer the potential of greatly increasing the capacity of the county agent to assist the commercial farmer with more complex and sophisticated problems.

The burden of the responsibility for orienting the new county agent and keeping all agents competent in subject matter will continue to rest on the state extension specialists. Departments in the college of agriculture will be challenged to find the resources and expertise to keep abreast of the fast moving developments in the technology and structure of agriculture.

Opportunities for innovative program development between extension and other groups need to be explored vigorously. Commercial farmers can and will pay for educational service activities. Some examples are the farm business management services, computer-assisted decision programs, marketing price data, and outlook information.

Extension is not the only source of agricultural information available to farmers and in some areas it is not the most important. Extension must reassess its real strengths and make adjustments to assure a high quality program. This could mean dropping some programs completely, teaming up with private business to find sufficient resources to impact on a problem, and cooperate with other agencies to assure maximum return from the investment of public funds.

The unique educational concept of extension is as valid today as it was in Seaman Knapp's day. Program development must begin with local people. Research is the key to solving problems and extension's educational programs bring about change—change in the capacity of people, change in quantity and quality of information, change in the speed and efficiency of knowledge transfer.

The extension teacher is crucial in this educational process. The individual must grow in technical competence while holding on to the mastery of program development and communication. In an age of rapid change and greater specialization, it is urgent that extension maintain a great degree of flexibility so programs can be adjusted to the changing needs of farmers and the rural communities.

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The Computer—Extension's Delivery System of the Future

H. G. Diesslin

You can hardly pick up a farm magazine today without seeing stories on "Computers—Newest Farm Implements," or some such title. Major TV advertisements during the Super Bowl heralded the arrival of computers for the family farm. Salesmen are stumbling over each other with hardware to sell; when discussions about the accompanying software necessary to make the hardware useful are opened, the salesmen quickly change the subject.

Yet, looking ahead over the next decade or two, the arrival of the computer on the farm, with the vital software necessary, will be a significant—perhaps the most significant—technological innovation on the family farm during that period of time. The magnitude of its potential is difficult to behold and certainly defies description at this point in time. The major question remaining at the moment is: "When will the knowledge base of American agriculture—the land-grant universities and the U.S. Department of Agriculture (USDA)—turn their collective talents to building viable software to allow the computer to function on the American family farm?"

Robert C. Kramer, program director, W. K. Kellogg Foundation, makes the following predictions for 1990:

> Three-fourths of all the mid-size farmers in the United States in 1990 will utilize computers or programmable calculators in helping make management decisions on their farms. . . .
>
> Many of the farming operations will be computerized and by electronic controls the operations will be automated. . . .
>
> There will be intelligent terminals in 90 percent of the county extension offices in the United States. . . . Virtually all of the departments of the Colleges of Agriculture and Home Economics will have terminals and/or small computers. . . . U.S. agriculture probably has the honor of being the top industry in the United States where the end-users (farmers) know more about computer programs. . . . By 1990, the gap will widen. . . .

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> Computer marketing or electronic marketing will be commonplace in 1990. . . .
>
> Regional development and sharing of software, regional sharing of specialists and regional computer networking will be commonplace in 1990. . . .
>
> For extension personnel who pioneered in the agricultural computer field during the past two decades, there were frustrations and disappointments. It will take hard work and patience, but U.S. farmers and their families will benefit from computer programs developed by the land-grant system.

Extension's Delivery Systems

The demonstration technique innovated by Seaman Knapp ultimately catapulted into an institution called the extension service. This technique is still central to the institution, although it continually undergoes modification with changing times and technology.

Other delivery systems—though secondary to the demonstration—are significant vehicles in the educational mission of the extension service. Among them, the following warrant separate comment:

(*a*) The extension bulletin (call it what you want). It was free; in the early decades of the century, it constituted the rural library of America. No longer free in many states, and no longer a monopoly as an information source, it remains an important delivery system for extension education.

(*b*) Penalty mail, often referred to as "free mail." Through the decades this has been an important partner to the free publication. Since the early 1970s it has not been free; it costs the same as regular mail. The only thing uniquely representing its importance in our history is the symbol, the penalty mail eagle on the envelope. As we discuss this topic today, ECOP is considering allowing states to discard the symbol and move to stamps in the near future.

(*c*) The "meeting" throughout the year, but particularly throughout the winter months, is and remains central to the extension educa-

tional program. Though the meeting technique ebbs and flows with the state of the economy—high energy prices are momentarily of concern—it, like the demonstration, is central to the educational delivery system of cooperative extension.

The decade of the 1980s gives the cooperative extension services an opportunity to establish a new, significant delivery system, the computer. We dare not "pass"; further, we have an opportunity to reestablish our leadership in the mainstream of American agriculture. Thus, I have elected to concentrate my remarks on the Indiana extension experiment with the computer over the past five years.

The Story of FACTS

The background of FACTS, Fast Agricultural Communications Terminal System, begins when the Purdue University School of Agriculture, including the cooperative extension service, initiated its original adaptation to computers in the 1950s and 1960s. This involved the use of teletypes, "dumb terminals," in scattered counties and area offices in the cooperative extension service around the state. Interaction was possible through long distance calls to the Control Data Computer (6500) which served the entire university. This involved a long learning process, basically on the part of our farm management staff in the field. Other agents essentially did not know the computer existed and had no hands-on experience with it. There were problems at the computing center at the university; in many instances there were long waits with open long-distance lines and, obviously, considerable costs involved before programs were run. Further, this system was not capable of out-of-state use, like AGNET in Nebraska or TELPLAN at Michigan State University, because of the way the system was programmed. From the standpoint of extension, there were only two major departments in the school of agriculture that made much use of it—Agricultural Economics and Animal Sciences. Our faculty in the Agricultural Economics Department developed complex crop and financial models that could be run and interpreted by our specialists. The "Top Farmer" program was widely acclaimed throughout the Midwest. Animal Sciences used the system for least-cost ration formulation, judging results, carcass evaluation programs, and the like.

This system involved the scientist with ideas, a programmer to implement his ideas within the capability of the machine, and few other constraints. There was little compatibility from program to program and little transferability from scientist to scientist or agent without intensive training.

In the late 1960s and early 1970s, the Purdue agricultural complex moved into a new phase of computer technology. This was the adaptation of the "intelligent terminal" to agricultural research. Through a grant from the National Science Foundation, we established PROJECT MIRACLE (Multidisciplinary Integrated Research Activities in Complex Laboratory Environments) to serve the Indiana Agricultural Experiment Station research and service laboratories throughout the Purdue agricultural complex. This system at the present time encompasses 20 laboratories, 50 terminals, and more than 260 researchers. The research performed with MIRACLE support led to the development of information which has been incorporated with extension service teaching materials. It makes possible certain FACTS activities, for example, the collection of data from the National Weather Service which is now sent out daily to the FACTS terminals throughout the state. More important, PROJECT MIRACLE developed and provided a wealth of experience to personnel who would later become involved with the FACTS project.

This project, which originated in the Animal Sciences Department, was quickly adapted by physical science departments (their first experience in many instances with the use of computers). This system involved new instrumentation—the minicomputer at the source of the research—in the greenhouse, in the weather station, at the lab. In addition, it involved an intermediate intelligent terminal for data storage and processing along with an automatic linkup with the university computer center. Once the program was written and verified, this removed much of the human error in complex program solving. It allowed what I call "machine to machine" research to begin to develop. Further, it led to complex interdisciplinary research undertakings with important extension applications which have now followed.

MIRACLE gave us experience with intelligent, low-cost computers, and it gave many scientists an opportunity to learn the technology of their use. Extension applications be-

came apparent. Networking was in its infancy throughout the country, but the hardware requirements were now becoming available. With this background, staff capabilities were available at Purdue University to lead such a new program. Thus, we were ready to move forward with a proposal to the Kellogg Foundation for the joint venture we now call FACTS. Compared to the typical university grant venture, I would classify this as "high risk." The Kellogg Foundation was not easily convinced that they should be jointly involved in such an undertaking. They had pioneered computer work in the Cooperative Extension Service fifteen years earlier with Michigan State University in a program that led to TELFARM and TELPLAN. The proposal was approved after lengthy discussions and an intensive site visit that laid out the plans in some detail; thus, in August 1976, the FACTS program of the Indiana Cooperative Extension Service was initiated under the sponsorship of the W. K. Kellogg Foundation.

General Mission

The objective of the FACTS system is, basically, to identify those circumstances in which the unique capabilities of the computer enhance or improve the basic function of extension. In the initial phase for implementing FACTS, the following guidelines were established.

(*a*) In information communication, FACTS will be used in instances where speed and currency are of primary importance in making information useful. It is not to be used to replace the printed word, mail, or telephone for the general distribution of information.

(*b*) In memory applications, FACTS will be used for operational management situations in which large quantities of repetitive material are used, such as mailing lists, program enrollments, and instances where regular, periodic, minor updating of technical bulletins is necessary.

(*c*) In its problem-solving capacity, the potential use of the FACTS system far outreaches the resources available. In the immediate future, development priorities will concentrate on (i) those instances in which individualized data of the client is helpful to his decisionmaking; (ii) those situations in which the limited specialty resources either on the campus or in the field preclude effective personal teaching relations (thus, FACTS can be a true *extender* of scarce resources to great numbers of clientele with specialized problems); (iii) those situations in which there is a reasonable time of operation and simplicity of user input (The programs should also have broad and long-term use.); (iv) Those situations which are complex and require the interaction of several disciplines or specialties of campus staff, including other computers.

The Scorecard

The Indiana Cooperative Extension Service, through FACTS development during the past five years, now has intelligent terminals in 100% of its counties and 100% of its agricultural and home economics departments, all tied into a networking system by private telephone lines.

Compared to the typical university grant venture, FACTS would have to be classified as a very "high risk" undertaking. By the end of the fifth year, 31 August 1981, more than \$5.5 million will have been involved from three major sources—Kellogg Foundation, \$1.9 million; Purdue University \$1.6 million; and the County Cooperative Extension Services, \$2.1 million.

An undertaking of this magnitude impinged on all existing academic departments and the entire field staff. It involved formation of a whole new department—Ag Data Network—composed of nearly two dozen professionals to develop, implement, and operate the system. Yet, without the simultaneous development of software by the extension specialists and departmental programmers, there would be nothing to implement. Further, the user clientele—county extension staffs—who purchased the equipment were at risk with their support groups unless they had numerous, high-quality software programs for their local machines.

We currently have more than fifty software programs available at the county level throughout the state. We are bringing approximately two new programs out each month, and the quality of the software is now approaching our intended standards of excellence.

We faced a dilemma in putting this operation together. I describe it as integrating a complex highly structured component into a highly unstructured academic and field staff educational program, the cooperative extension service.

After several years of frustration—near chaos at times—it is nice to see "light at the end of the tunnel." Adding a subsidiary to the corporation is not easy. It if had been easy, it would have happened a long time ago somewhere in these United States. At this time, less than five years from inception, a fully integrated, intelligent computer network is now in place and operational.

Looking to the Future

With a computer in every county and area office and in our academic departments, can we service the educational opportunities of our extension clientele, the citizens of Indiana? Obviously not. These units just represent the "tip of the iceberg." To be used effectively, the computer ultimately must be located with the end user, on the farm, or in the home, for example. How do we move it from the extension office to the end user, and why?

Critical to successful agricultural computer programs is relevant software for problem solving. The knowledge generator for American agriculture is the Agriculture Experiment Station and the Cooperative Extension Service of each state in cooperation with the U.S. Department of Agriculture. Thus, these institutions must assume the responsibility of translating research and information into software packages applicable to family farms and related agricultural production and marketing institutions.

By making our computer programs available to all our clientele through our extension offices, we are now able to provide the same programs to the individual to use on his own computer, at his own expense of course. Under such an arrangement, we are not open to criticism for working with only a special sector of our agricultural clientele. Each state, and the nation, must face this major policy issue in a consistent manner through the Land Grant-USDA partnership.

Looking ahead, in Indiana, a possible second step is to make our software information and programs available to vocational agricultural departments that are financially able and ready to purchase compatible equipment in their high schools. This would serve both an educational function—giving high school students hands-on experience with computers—and problem-solving opportunities for the home farm.

The third step involves getting the computer on the farm itself, into the hands of the end user. This becomes possible when our software packages are of sufficient economic value to justify the purchase of farm computers. An agricultural computer association, similar to farm accounting and farm management associations common in the Corn Belt, is one form such an end-user group might adopt. Members would own their own equipment, including the central switching and computing center serving their association, and they would purchase their software packages from the land grant institution servicing their state. Related services would be purchased from other suppliers. Over time, some users would develop the capacity to write some of their own software programs.

By making all programs available through our extension offices, we can, without public antagonism, work with those who can afford their own and add a new dimension to the competitive efficiency of American agriculture. We look forward to a pilot effort, putting the computer on the farm, in the not too distant future in Indiana.

Policy Issues

Policy issues facing the adaptation of the computer to American agriculture are many and varied. A few that have surfaced as we struggled with FACTS over the past five years include:

(*a*) Do we all need to "reinvent the wheel" in order to get started? Our grant with Kellogg Foundation involved developing a prototype extension networking system with intelligent minicomputers. The networking system necessarily was developed from the ground up to make the system functional. The cost for developing the networking system alone will total close to $2 million before it is completed; and, more important than the monetary cost, it will take more than four years to accomplish. Does every state need to start from the beginning and invest this kind of time and money to put a system into operation?

States interested in establishing a network with compatible or near-compatible equipment can save two to three years startup time and much of the $2 million cost. As a prototype system, we stand ready to transfer our present technology to any extension service compatible system at comparatively nominal costs.

(*b*) Do we not have a right, perhaps an obligation, to share software? Software packages are expensive in the development stages. Whether or not to copyright our software was another major policy issue in Indiana. There seem to be as many copyright policies in existence as there are universities. We decided to copyright our programs and are currently doing so. We are doing it for the following reasons: to carry the university name and reputation with the programs developed; to give further credit to the "creators" or "developers" of the programs in the university review system; and to allow franchising in the commercial or private sector if the program has widespread appeal and proprietary value that should be protected for the university and inventor. The protection of a computer program itself through the copyright policy is of minimal value.

Our copyrights, signed by the creators and department heads and agreed to by the university, carry the following exclusion for each copyrighted program: "Permission is given to Purdue University for use of said materials in any non-commercial or educational activity including but not limited to the University relationship to and function in the cooperative Extension Service which would include cooperation with any other state cooperative Extension Service for non-commercial or educational purposes."

Thus, our programs are available for other cooperative extension services on the above terms at nominal costs. This remains true even where a private franchising agreement has been consummated.

(*c*) Can we establish and carry out documentation standards that allow program interchange at minimal cost? We have established standards and procedures for documentation that are unique before a program will be used in our FACTS system. The documentation is such that the program can be adapted to any computer system (of sufficient size) or language with very minimal effort. Such standards are not now present in our land grant universities or cooperative extension services.

(*d*) Can we arrange multistate programming in areas of similar agriculture—the Corn Belt or Great Plains, for example? Large land areas in the United States have common types of agriculture, e.g., the Corn Belt, the Lake States, and the Great Plains. The real scarcity in agricultural computer development is the number of scientists and specialists available to create relevant programs to make a viable system. If groups of states with common types of agriculture would develop compatible systems, each would have the best scientists' programs from all the states in the region. If we could implement the Midwest Plan Service or Swine Industry Handbook concept to computer programming, what a magnificent breakthrough this would be for our extension services, and, more important, our farm clientele across the nation. We need this sharing of development resources in Indiana today and stand ready to assist in any such undertaking.

The development of regional centers, such as the North Central Computer Institute, will allow us to address issues similar to these and find solutions mutually beneficial to our ultimate clientele.

Changing Delivery Systems for Agricultural Extension: Discussion

John Holt

Plaudits to the program planners as well as the authors of the three papers! The papers fit together into an interesting mosaic that points a direction for future extension delivery systems. My role is merely to highlight their inherent continuity, and to emphasize a point about where to concentrate limited extension resources as that direction is followed.

The papers should be read in order: Hildreth and Armbruster give an overview of how we got where we are that, happy surprise, is not boring. At least one-half day of any New Agents' Training Conference could be replaced by reading their one sentence gem: "The major principles of extension programming (are) involving students in program development, presenting education in an informal setting, and focusing on practical information." And they conclude with the central problem of the future: The need for delivery innovations "will continue growing faster than funds."

The casual reader may need reminding that the bulk of Hildreth and Armbruster's remarks apply primarily to county extension work. But Brown sharply separates his remarks about county, area, and state professionals. The "age-old" extension problem is one of program balance between selected audiences, along with developing the necessary staff competence. Brown's analysis rests on the same rails as the first paper: "The harsh reality is that extension will have to operate with less. . . . Extension must," according to Brown, "reassess its real strengths and make adjustments to assure a high-quality program. This could mean dropping some programs completely. . . ." The difficulty of doing so was plaintively sounded almost a decade ago by Sprott: "The typical Extension Service worker . . . seldom if ever discontinues doing any thing. Most Extension programs are taken on in addition to rather than in place of a current program" (p. 55).

Brown sagely observed that "The new developments in electronics communication, individualized learning, data storage, retrieval, and analysis offer the potential of greatly increasing the capacity of the county agent to assist the commercial farmer with more complex problems." The stage is set for Diesslin, who enthused that the arrival of the computer on the farm offers potential that "is difficult to behold." Surely, we can agree, and we can all fervently hope with him that with the computer, "we have an opportunity to reestablish our leadership in the mainstream of American agriculture." And those of us who do not have elaborate (or in some cases, even infantile) systems can be grateful to the Kellogg Foundation, to Purdue, to Oklahoma State, to Michigan State, and to those other pioneers in computer applications in agriculture from whom we can borrow.

Let no beginning state extension specialist ignore the guidelines that Diesslin lays out for implementing the FACTS system, particularly those dealing with using computers in their problem-solving capacity. Those guidelines could save years of floundering.

So the computer can save us. But how? The life raft is simply too small for all of extension's programs. Some tough choices must be made about the audiences that will be served. Some programs will have to be dropped: indeed the Florida legislature has mandated that some nonagriculture programs be dropped. Hildreth and Armbruster's notion of abandoning the large producers should be dropped, as should those ideas Brown emphasized from *A Time to Choose*. Concentrating on our comparative advantage means working with commercial agriculture, which made extension what it is (Holt, Pugh, Brant).

In the future, should not our response be like the popular girl at the country dance? She refused all new suitors with the words "No, I'll dance with who brung me here."

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Changing Delivery Systems for Agricultural Extension: Discussion

Harlan Hughes

The three papers presented accurately describe (*a*) extension's philosophy and goals, (*b*) extension's staffing and expertise needs, and (*c*) Indiana's FACTS computerized delivery system. Although the papers presented by Hildreth and Armbruster, Brown, and Diesslin address different issues, they all perceive problems which impair the flow of research information to our clientele. The purpose of my discussion is to probe further into these problems and to suggest possible means for improving information delivery systems for extension.

Hildreth and Armbruster point out that extension is generally oriented toward the middle-size farms, which are shrinking in number and potential strength. They suggest extension may well forget about serving large producers. In my opinion, the survivability of the West's long-run extension programs hinge on gaining the support of the large producers. Their political support is much stronger than what the numbers indicate. These are the clientele that will speak out for (or against) extension in public hearings. Strong testimonials are going to be needed to keep extension's present resource base.

Hildreth and Armbruster state that "extension is a linkage between research and the users of knowledge." The complexity of many of today's research projects requires the extension specialist get involved early in the research phase. It is becoming more and more difficult for an extension specialist to use the results of a finished research project to serve his or her clientele. This, in my opinion, is the strongest support for joint extension/research appointments.

Brown argues that the potential for mounting successful extension programs rests more with in-service training than with recruiting more specifically trained county staff. Professional improvement programs are extension's primary investment in human capital; however, very few state extension services are making major investments in professional improvement programs. I believe extension staff, particularly agents, should spend at least thirty work days a year in professional improvement programs.

"Research trained Ph.D.s are inadequately prepared to meet the challenges and responsibilities of state extension specialists." If Brown is right in this statement, this may have a profound implication for the long-run survival of extension education. Extension may need a national training center to teach state specialists how to be state extension specialists. A small amount of "how to teach" could greatly enhance a young extension specialist's extension program. Some form of a national "Winter School" for state specialists could greatly expand extension's human capital.

Diesslin presented a good overview and considerable insight into the FACTS system. The integration of research into extension software greatly enhances the value of computerized decision aids in extension. Purdue's pioneering effort in this area with its MIRACLE system is extremely significant. Research can and must play a major role in the subject matter content and the associated data bases used in extension's computer models. Without it, our computer delivery systems will fail due to information voids.

Extension has a proud history and has played a major role in American agriculture. We are not, however, without our problems. Hildreth and Armbruster, Brown, and Diesslin have drawn our attention to some strengths and weaknesses of extension. By capitalizing on these strengths and working on the weaknesses, extension can continue to play a major role in agriculture.

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On the Power of Macroeconomic Linkages to Explain Events in U.S. Agriculture

Bruce Gardner

The significance for agriculture of macroeconomic events in the 1980s depends upon what elements in the macroeconomy are most strongly linked to agriculture and how these linkages function. It is idle to say, for example, that inflation poses particularly serious problems for agriculture in the 1980s unless we have evidence that inflation generally causes particularly serious problems for agriculture. This paper concentrates on the past literature and current state of evidence on such questions. The final section considers the possibility of scientifically defensible forecasts for the 1980s. It is short.

Theories of "Sectoral Macroeconomics"

Many economists have emphasized the importance of not treating the farm sector as a partial-equilibrium island, and a few have worked diligently at building the needed analytical and empirical bridges. Notable early examples are Kirk, Schultz, Hathaway, and Firch (1964), all of whom linked agricultural instability to business cycles. The period in which Hathaway and Firch wrote was the high-water mark of the "Keynesian" approach to these issues, which emphasized the uses of macroeconomic policy. Following the recent disintegration of the theory of macroeconomic policy, the theme of macroeconomic instability returns. Some prominent hypotheses are: "Instability in farm income has its origins chiefly in business fluctuations" (Schultz, p. 214). "Agricultural prices and income are not extremely sensitive to [macroeconomic] changes" (Lamm, p. 30). "National inflation exerts a real price effect on the farming industry, reducing the parity ratio" (Tweeten and Griffen, p. 10). There is also the denial of the preceding hypothesis (Schluter and Lee); "inflation dampens productivity growth" (Ruttan, p. 896); and the denial of this hypothesis (Johnson). Schuh (1974) saw the exchange rate as an important determinant of real farm prices. Other hypotheses are that "inflation has contributed to a greater degree of inequality among regions and types of farms" (Robinson, p. 904); "the major long-run effect of inflation is perhaps in the way it affects the prices of fixed assets, primarily land for agricultural purposes" (Penn, p. 892); and that inflation "leads farmers to expand their operations more aggressively" (Schertz and Harrington, p. 64).

The derivation of these hypotheses tends to be theoretically ad hoc, as well it might be since standard macroeconomic theory provides little guidance. The empirical evidence adduced has been sparse and contradictory. There is a general hypothesis that instability in aggregate demand causes instability in relative commodity prices, which is supported by recent research (Vining and Elwertowski, Parks). Consequently, we expect real farm prices and incomes to be more variable when the general price level is more variable, as Firch (1977) indeed found. But the effect of macroeconomic disturbances on the level of real farm prices and incomes remains an open question.

Systematic connections between macroeconomic aggregates and sectoral variables may occur along the following lines: if an unanticipated exogenous event occurs (such as accelerated growth in the money supply), there will be a sequence of price and interest rate adjustments throughout the economy that will affect some sectors earlier than others. If these transmission mechanisms are stable—perhaps functions of capital intensities, industry structure, prevalence of long-term con-

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tracts, or other specific characteristics of the industry—then we expect a particular time path of adjustment in agriculture (and each other sector) in response to such shocks. Thus, farm prices will rise faster than nonfarm prices if the transmission mechanism works in certain ways, e.g., if prices in competitive auction markets adjust more quickly than prices in imperfectly competitive markets.

The roles of long-term contracts and differential changes in anticipations can be incorporated in a general discussion of price elasticity of supply and income elasticity of demand as determinants of macroeconomic influence on a particular sector. The ideas go back at least to Cairnes, who associated price transmission with sector-specific demand impacts and short- and long-run supply elasticities (see Bordo). The predictions of this approach are not as straightforward as they may appear at first glance. For example, one might expect farm prices to increase rapidly in response to an unanticipated increase in aggregate demand because intended crop output is costly to change during the period when crops are growing. On the other hand, shocks can be buffered by changes in stocks or international trade. Moreover, many nonagricultural goods are subject to relatively fixed capacity constraints in the short run, and long-term contracts with prespecified nominal prices appear more prevalent in nonagricultural industries. In short, while we expect sector-specific price effects of some kind, it is a matter of empirical investigation to discover what these effects are.

The null hypothesis in this situation does not incorporate a "wrong" sign for any variable (hence two-tailed statistical tests are appropriate). Alternative null hypotheses are that all sectors respond to macroeconomic shocks at about the same rate; or that the differential responses are random, so that a sector that gains in one inflationary episode is just as likely to lose in the next. Unfortunately, independent inflationary episodes are scarce. While the years 1960–76, for example, contain sixty-eight quarters, they may contain only four or five underlying inflationary shocks, and hence give only a few degrees of freedom in studying sectoral redistribution. This is probably why Tweeten and Griffen can obtain "statistically significant" results that the parity ratio falls under inflation, while Schluter and Lee find the opposite results for a more recent (but shorter) time period.

While the fewness of inflationary episodes suggests the use of a lengthy time series of data, this increases the likelihood that structural change has occurred during the period being considered. So we are presented with the following dilemma in empirical work: a short time series is unlikely to provide generalizable results about macroeconomic effects because there will be too few significant macroeconomic events; but in a long period the structure of agriculture may have changed so much that there are no generalizable results.

Some macroeconomic hypotheses involve factor-market linkages, e.g., there is "an increasingly close link between the rural sector and the general economy by means of factor markets" (Gardner, p. 22). One of the few sectoral models to emphasize these linkages is Lamm. The ideas derive from Walrasian general equilibrium rather than Keynesian models, involving sectoral linkages more closely related to standard supply and demand models. In particular, we expect labor returns in the farm sector to be strongly influenced by nonfarm labor returns, and the rate of return to investment in agriculture to be closely linked to rates of return in the general economy.

Data on Agriculture in Recessions and Inflations

Table 1 shows in calendar-year aggregates what happened in U.S. agriculture during recessionary and inflationary periods. A year is defined as recessionary if real GNP fell from the preceding year (except 1947 and 1949). To define an inflationary period, I considered two criteria. The first is the set of years when the year-over-year CPI increased 4% or more. The second is the set of years in which the actual rate of inflation exceeded the anticipated rate of inflation, i.e., when unanticipated inflation occurred. This criterion derives from the "rational expectations" view that people adapt to anticipations such that only unanticipated changes in the inflation rate have real effects. For example, because of experience in the early 1970s, an inflation rate of perhaps 6% was generally anticipated for 1977, so that interest rates, rental rates on capital, and so forth reflected this expectation; and had the inflation rate turned out to be 6%, all prices would have adjusted without dislocations of real economic activity. What makes

Table 1. Economic Indicators of the Farm Sector in Recession and Inflation

Year	Real Farm Prices[a]	Real Net Farm Income	Real GNP	Real Farm Land Price	Real Farm Wage Rate	Real Nonfarm Wage Rate
	(% annual change)					
Regressions[b]						
1974–75	+14.4	−29.1	−1.8	+7.6	+1.1	−1.3
1970	−4.0	−7.0	−1.4	−2.3	+1.5	−0.9
1958	+3.6	+11.7	−1.4	+3.6	+2.9	+1.9
1954	−3.6	−5.2	−0.5	−4.3	−2.2	+1.8
1949	−14.2	−36.9	+0.6	+3.2	−1.0	+4.6
1938	−24.0	−35.1	−3.9	+1.9	+1.9	+1.9
1930–32	−21.3	−35.0	−12.3	−2.0	−13.8	−0.6
1927	−1.7	−2.2	−1.8	−1.1	+1.9	+1.9
1924	−0.2	−4.6	−0.2	−3.0	+4.6	+3.5
1921	−30.3	−46.1	−9.3	+2.3	−1.1	+3.4
1914	−1.3	+9.4	−3.9	−1.3	−1.3	−1.3
Average	−11.3	−24.2	−4.9	+0.6	−5.2	+0.8
Inflation years[b]	+2.8	+0.9	+3.5	+1.3	+3.4	+2.2
Unanticipated inflation[b]	+3.1	+4.0	+3.4	+1.1	+2.4	+2.4
All years, 1910–79	−1.1	−2.6	+2.9	+0.8	+1.3	+2.1

[a] "Real" means deflated by the consumer price index. Sources of data: U.S. Department of Agriculture, U.S. Department of Commerce, and U.S. Council of Economic Advisers.
[b] For definition of "recession," "inflation years," and "unanticipated inflation," see text.

1977 an inflationary year is that the inflation rate accelerated to 9%.

To estimate anticipated inflation, I fit an ARIMA model to natural logs of the CPI. The anticipated rate of inflation is the forecasted value for each year from the differenced CPI time series. The ARIMA (1,1,1) model over the 1910–79 period is

$$I_t = \underset{(0.158)}{0.314}\, I_{t-1} - \underset{(0.138)}{0.554}\, e_{t-1} + e_t,$$

where I_t (= change in log CPI) is the rate of inflation in year t, and e_t is the forecast error. The numbers in parentheses are standard errors of the coefficients. The forecast for I_t is made as soon as I_{t-1} and e_{t-1} are observed. This specification fits better than a simple first-order autoregressive or moving-average process (i.e., adaptive expectations), or a random walk as used in Parks (p. 90). But higher-order AR or MA lags do not significantly reduce forecast errors, and the autocorrelations of the residuals from the fitted model are not significant.

Given the ARIMA forecast as the anticipated rate of inflation, years of unanticipated inflation are defined as those in which the actual rate exceeds the predicted rate by one standard error (3%) and in which the rate of inflation was positive (to exclude decelerations of deflation in 1922 and 1934). These years are 1916–20, 1941–42, 1946–47, 1951, 1971, 1973–74, 1977–79. The years in which the CPI rose more than 4.0% are the same except that 1943, 1948, 1969–70, and 1975–76 are added. Note that 1970, 1974, and 1975 are years of simultaneous recession and inflation under one or both criteria of inflation. And of course there are many years, forty-six out of seventy in the 1910–79 period (although only one in the 1970s), in which neither inflation nor recession is observed.

The performance of agriculture during recessions is variable, as the table 1 data indicate, but on average the farm sector fares poorly during these episodes. Farm income tends to fall substantially more sharply than overall GNP, as do farm prices relative to the general price level and farm wage rates relative to nonfarm wage rates. Thus, it appears that agriculture has an even greater stake than other sectors in avoiding recessions, although the differential effects are less pronounced since 1950. (The substantial farm income decline in 1974 is misleading, being measured relative to the extraordinary year of 1973. 1974–75 was still well above 1970–72 in real farm income.)

The effects of inflation are roughly similar under both criteria for inflation. For the nonfarm variables and for farm wage rates and land prices, the inflationary periods do not differ appreciably from the seventy-year mean rates of growth. However, real farm product

prices and real farm income grow faster in the inflationary years, particularly in years of unanticipated inflation.

Econometrics of Macroeconomic Linkages

Two serious deficiencies of the table 1 data are that they provide no indication of the statistical significance of the observed differences, and they leave out everything else that happened during recessions and inflation besides these macroeconomic events. In an attempt to remedy these deficiencies, this section develops regression models for these data. Table 2 shows results for real farm prices. Regression 1 indicates effects of about the same magnitude as the averages reported in table 1, but the effect of inflation is not statistically significant. This is the same result found by Grennes and Lapp.

Regressions 2–7 include other variables that may be influencing farm prices. The variables added in regressions 2 and 3 pertain to long-term forces underlying U.S. farm prices, while regressions 4 and 5 add variables on output changes and exports, which may be more important in determining short-term price fluctuations. Output changes clearly influence price changes but also are clearly endogenous variables. However, it seems likely that output changes contemporaneous with farm price changes are caused primarily by weather, or similarly exogenous forces, rather than being production responses to contemporaneous price changes. Lagged output is included along with current output because the calendar-year basis of the price index results in two crop years being relevant to the observed price change.

Exports also involve obvious problems of mutual determination with prices, but analysis of the time series did not detect causality going from prices to exports. For recent years, it is possible to include an additional export-related variable, the exchange rate of the dol-

Table 2. Regression Coefficients Explaining Percentage Changes in Farm Prices Received, 1910–78

Independent Variables[a]	Regressions						
	(1)	(2)	(3)	(4)	(5)[b]	(6)[b]	(7)
Recession	−.12	−.11	−.11	−.10	−.004	GNP 1.28	1.28
(dummy)	(4.2)[c]	(3.5)	(3.4)	(3.6)	(0.1)	(2.3)	(8.0)
Inflation 4+%	.04	.03		.03	.002	CPI 1.47	.47
(dummy)	(1.6)	(1.0)		(1.1)	(0.1)	(1.5)	(1.6)
Unanticipated			.03				
inflation			(0.9)				
Productivity		−3.5	−3.8	−3.2	.71	8.5	−.50
		(0.9)	(1.0)	(1.0)	(0.2)	(1.5)	(0.2)
Nonfarm		.49	.47	.45	−1.1	−2.6	−.52
wage		(1.4)	(1.3)	(1.3)	(0.6)	(1.8)	(1.8)
Government							
programs		.06	.07	.06			−.01
(dummy)		(1.1)	(1.4)	(1.3)			(0.2)
Exchange rate					−.39	−.42	
					(1.6)	(2.1)	
Exports				0.5			.03
				(1.1)			(0.9)
Output				−.12	.20	.66	−.44
				(0.5)	(0.4)	(1.6)	(2.5)
Lagged output				−.70	.32	.57	−.74
				(3.3)	(0.6)	(1.3)	(4.8)
R^2	.23	.31	.31	.43	.22	.44	.70
Durbin-Watson	2.18	1.61	1.60	1.46	2.06	2.20	1.57

[a] All continuous variables are percentage changes, so coefficients are elasticities. Definitions and sources of variables: recession and inflation dummies defined in text; productivity is USDA's index of total factor productivity, smoothed using a fitted fifth-degree polynomial (no trend in 1910s, gradually rising in 1920s and 1930s, accelerating in 1950s and 1960s, decelerating in 1960s and 1970s); nonfarm wage is Department of Commerce hourly wage rate in U.S. manufacturing; government program dummy is 0 through 1932 and 1 thereafter; exchange rate is the Federal Reserve Board's trade-weighted dollar; exports are U.S. Department of Commerce estimates of the value of agricultural products exported; output is USDA agricultural output index, 1967 = 100. All dollar variables except the exchange rate are deflated by the CPI.

[b] Regressions containing the exchange rate cover 1956–78 only.

[c] "*t*"-statistics.

lar for foreign currencies. An interesting literature has grown up around Schuh's hypothesis that an overvalued dollar was a prime cause of agriculture's problems in the pre-1972 period. Of the variables that have been suggested for use in testing this hypothesis, the most attractive is a trade-weighted dollar, an index of exchange rates of major currencies weighted by the share of trade accounted for by each country. Such a variable is included in regression 5. Since it is only available after 1956, this regression covers a much shorter time period than regressions 1–4.

The results are quite different for the shorter time period. Output, productivity, and nonfarm wages all become insignificant.[1] The most significant variable is the exchange rate, whose coefficient indicates that a 1% fall in the value of the dollar generates a 0.4% increase in real farm prices. Most important for the present discussion, there is no longer any significant effect of being in either a recession or an inflationary period. This bears out what the table 1 data indicate for recessions—that they no longer are as important to the farm sector as they once were. This is consistent with the findings of Lamm. Regressions 6 and 7 include real GNP and the CPI as continuous variables instead of dummies for particular episodes. The results are basically similar, but the t-ratios and R^2 generally improve.

Table 3 contains regressions explaining real farm income, wage rates, land prices, and prices paid by farmers. The recession coefficients tell the same story as the raw data of table 1–the significant effects are to reduce the real farm wage rate by about 5% and real farm income 23%–24%. The effects of inflation are insignificant on all the real variables (also true for years of unanticipated inflation, although to save space these regression results are not shown). This conflicts with Tweeten, who found inflation to increase real prices paid by farmers.

Regressions 9 and 13 show results for the

[1] The F value for the short-period residuals is 0.76, indicating insignificance for the regression as a whole. Seemingly much "better" results occur with regressions on levels rather than changes. Regressions 5-6 specified in terms of levels yield much higher R^2. But the Durbin-Watson statistics are less than the R^2, indicating that "significance" of results and apparent good fits may be spurious. (See Granger and Newbold, pp. 202–14.)

Table 3. Regression Coefficients Explaining Annual Percentage Changes in Farm-Sector Variables

Independent Variables[a]	Dependent Variables[b]: Real Net Farm Income (8)	Real Net Farm Income (9)	Real Prices Paid by Farmers (10)	Real Farm Wage Rate (11)	Real Farmland Price (12)	Real Farmland Price (13)
Recession	−.23	−.14	−.03	−.05	.01	.003
	(4.0)[c]	(1.2)	(1.8)	(2.2)	(0.9)	(0.1)
Inflation (4%)	−.002	.06	.004	.01	−.01	−.04
	(.04)	(0.7)	(0.3)	(0.5)	(0.4)	(1.5)
Productivity	−2.6	26.6	−1.87	−1.14	−2.49	−7.8
	(0.4)	(2.3)	(0.9)	(0.5)	(1.4)	(2.5)
Nonfarm wage	.71	−2.8	.29	.70	−.14	−.12
	(1.0)	(0.5)	(1.3)	(2.7)	(0.9)	(0.1)
Gov't. programs	.05		.04	.05	.08	
	(0.5)		(1.3)	(1.6)	(3.6)	
Exchange rate		−4.3				.34
		(6.0)				(1.8)
Exports	.08		.07	.07	.04	
	(0.8)		(2.4)	(2.0)	(1.6)	
Output	1.02	1.09	.02	.39		
	(2.2)	(0.8)	(0.2)	(2.3)		
Lagged output	−1.35	.63	−.35	−.00		
	(3.2)	(0.4)	(2.6)	(0.0)		
R^2	.50	.76	.32	.41	.34	.31
D-W	1.67	2.36	1.32	1.88	1.75	1.89

[a] Same as in table 2.
[b] Net farm income is the USDA's estimated total net income from farming. Prices paid is the USDA index for production items. The farm wage rate is the USDA index, as is the farm real estate price. All are deflated by the CPI.
[c] "t"-statistics.

1956–78 period. The recession effects are weaker in this period. Note that the exchange-rate variable is highly significant, as it was in the output-price regression. However, in the land-price regression, the exchange rate has a positive sign, which means that depreciation of the dollar is associated with lower land prices, an unexpected result. Note also that the land price is the only dependent variable in the table 3 regressions for which the government-program dummy has a significantly positive effect. The hypotheses that inflation increases the real prices of fixed assets and the rate of growth of farm size (Penn; Schertz and Harrington) lack evidential support. While the raw data of table 1 show real estate prices rising 1% to 2% faster in inflationary years, regressions 12 and 13 show no effects of inflation on real land prices.

Alternative econometric specifications to those of this paper include the following: one could model less aggregated commodities, as in Chen; one could imbed the farm sector in a fuller model of the rest of the economy, as in Cromarty, Fox, Shei and Thompson, or Lamm; or the specification of the foreign market influences on the U.S. farm sector could be more complete, as in Grennes and Lapp. A detailed model of the agricultural sector, fully integrated with a model of the general economy, would permit study of macroeconomic effects on agriculture simultaneously with the effects of agriculture on the rest of the economy. An assumption of my regressions is that a fully specified model is not necessary to identify macroeconomic effects upon agriculture. Because agriculture is a small part of the general economy, the dominance of causality from the general economy to agriculture seems plausible, but fuller models are necessary to test the assumption.

A few small-scale simultaneous models have been developed, notably Lamm, Shei and Thompson, and Chambers and Just. I have found the results in these papers suggestive but inconclusive in establishing the nature of sectoral linkages. Chambers and Just find that "a sustained 10 percent reduction in domestic credit would eventually evoke more than a 17 percent change in the level of wheat price, a 7 percent change in corn price and an 11 percent change in soybean price" (p. 17). This is a quite implausible result, and it is not clear that the differences are statistically significant. Shei and Thompson conclude that Soviet grain purchases had a substantial effect on the general price level in 1973, while over a longer time period Lamm concludes that "changes in the rest of the economy have large effects on agriculture, while the converse is not ordinarily the case" (p. 32). Overall, the evidence adduced in these papers is far from settling the issues.

Firch (1977) considers subperiods of data that are suggestive of structural change over time in macroeconomic influences on agriculture. He finds, for example, that inflation was a more prominent agent of instability in 1920–39 than in 1946–75. The weakness of his approach is the lack of tests of significance for time-varying effects.

Evidence on instability is obtainable by a modification of regression 7 above in which the log changes of price, the inflation rate, and other variables are squared. This transformation generates a component of the log variance of price and other variables, so that a zero coefficient on an independent variable means that it contributes negligibly to variation in the dependent variable. A significantly positive coefficient on variability confirms the hypothesis of Parks that instability in the general price level generates instability in real sectoral variables. For the 1910–78 period, regression 7 as transformed yields a statistically significant effect of price-level variability increasing the variability of real farm prices. The shorter period 1956–78 as respecified shows a smaller instability effect, but a null hypothesis of no structural change in the regression coefficient over time cannot be rejected. The overall result is to confirm for agriculture the Parks and Vining-Elwertowski results that macroeconomic instability has real sectoral effects. But it remains the case that there is no predictable direction in which real farm prices are affected by general inflation.

Implications for the 1980s

In 1969, Egbert derived the following policy implication from his sectoral model: "Some form of production controls will continue to be needed in agriculture to maintain prices and incomes, at least for the next decade" (p. 31). The most convincing explanations of what happened to make this and similar forecasts look ridiculous in the 1970s are macroeconomic linkages. Are we now equipped to speak with any better authority about the 1980s? It would be rash to suppose so. But

there may be better prospects for preinterpretation of the 1980s, that is, projection of the kinds of influences that it will be most important to watch for, and forecasts conditional on salient contingent events.

In the research to date I see three main channels of influence from the rest of the economy to agriculture. They are (*a*) "Walrasian" influences—the forces associated with the attainment of neoclassical general equilibrium between sectors, most notably equalization of rates of return in factor markets; (*b*) "Marshallian" influences—the effects of standard shifters of supply and demand curves, such as consumers' incomes or population; and (*c*) "Keynesian" influences—a catchall for the nonstandard hypotheses such as those of Schultz, Firch, and Schuh.

The Walrasian view of agriculture's connection with the rest of the economy has not been as prominent in the recent literature as the Keynesian hypotheses. Nonetheless, this approach holds promise for preinterpretion of the 1980s. Schuh (1962) and many successor studies on farm labor indicate that the most important determinant of farm wage rates is nonfarm wage rates. More recent work, notably Melichar, Hughes, and Feldstein, is establishing the groundwork for similar conclusions in the capital markets. From this point of view, the most important determinants of the trend of farm factor returns in the 1980s will be factor returns in the general economy.

The Marshallian linkages dominate the early sectoral models of Cromarty, Fox, and Egbert, although they were developed in conjunction with Keynesian macromodels. The inflation rate, for example, does not enter into the determination of relative farm commodity prices, nor does the exchange rate or other nonstandard influences. This continues to be the case for large farm-sector models such as Chen's. Thus, preinterpretion of the 1980s using such models will not involve the issues which have been emphasized in this paper, except insofar as real GNP influences demand functions.

The main "Keynesian" variables that appear to possess explanatory power in the historical data are recessions and the exchange rate. But recessions are not important after 1950 (and GNP is not that nonstandard anyway). Moreover, on further consideration it is dubious whether one can expect future fluctuations in the foreign value of the dollar to play a major role in the real well-being of the farm sector in the 1980s. The reason is that the effect, for example, of the exchange rate in regressions 5, 6, and 9, above, results from the switch from a fixed to a flexible exchange-rate system, which took place in two steps in 1971 and 1973. (This is revealed by the fact that an exchange-regime dummy that captures only the fixed versus floating contrast picks up virtually the whole exchange-rate effect, while the exchange rate itself, in the presence of the structural-shift dummy, becomes insignificant.) So one cannot use the exchange-rate coefficient to forecast effects of future exchange rate fluctuations under the floating-rate regime. There may well be real exchange-rate effects, but these will turn on deviations from purchasing-power parity in exchange rates, a topic on which future research should be given high priority, but on which there is not yet enough knowledge to base forecasts.

The "Keynesian" preinterpretations of the 1980s that I have to offer are thus negative: even if I knew the future course of U.S. business cycles, inflation, and foreign value of the dollar, I could not predict any particular consequences for agriculture (compared to other sectors). Of course, to predict nominal prices, we need to forecast the general price level, and for this we need a macromodel. But there is no evidence that the best macromodel for the purpose has anything agricultural in it. Thus, there is no reason to believe that agricultural economists can forecast better by expressing their models in nominal values (as most of the papers cited in the list of references do) and then incorporating determinants of the overall price level such as the money supply on the right-hand side. With further research this situation may change, but for forecasting the 1980s at our present state of knowledge, I believe it preferable to use the macroeconomists' models for the economy-wide variables and sectoral models with deflated prices for agricultural variables. In short, the classical dichotomy between real and nominal values prevails in practical forecasting of annual data.

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Agricultural Land: Adequacy of Acres, Concepts, and Information

Michael F. Brewer and Robert F. Boxley

The authors were implicated to varying degree in the recent National Agricultural Lands Study (NALS). In addressing our assigned topic of the "adequacy" of agricultural land for the 1980s and beyond, we draw on the NALS experience.

NALS was a multiagency federal study under the joint sponsorship of the U.S. Department of Agriculture (USDA) and the President's Council on Environmental Quality. NALS was charged with determining "the nature, extent, rate and causes of reductions in the land base of U.S. agriculture," evaluating its "economic, social and environmental consequences," and recommending "administrative and legislative actions, if necessary, to reduce losses suffered by the nation as a result." As with previous efforts of this type, the root question prompting the investigation was whether the future consequences of current trends in land use warrant policy intervention in the processes that now allocate the resource.

This heavily publicized and widely reported exercise yielded multiple, and at times inconsistent, products. These include findings from staff research, various pamphlets and "Interim Reports," and a separately drafted *Final Report* that was filed in the closing hours of the last administration. The latter contained new forecasts of future land requirements based on last-minute revisions of previous projections by USDA.

The study furnished graphic examples of difficulties researchers can encounter in exploring subjects that many perceive as articles of faith, and that are suffused with vested interests and foregone conclusions (Cook 1980, 1981). Regardless of what the NALS *Final Report* advanced as findings and recommendations, history suggests they will not lay the issue to rest. As with debates on the need to control population or the limits to growth, agricultural land adequacy seems to have a cyclical claim on the public's imagination, anxiety, and credulity (Luten). We are not sanguine that the NALS will break that cycle. Efforts to determine the "nature, rate, extent and causes of reductions in the land base," led NALS into a morass of inconsistent and conflicting numbers that left issues possibly more confused than previously. Instead of a broad "economic, environmental, and social evaluation" of the consequences of agricultural land conversion, the *Final Report* based the substantive case for a federal role in agricultural land preservation almost solely on the question of when the nation "runs out" of suitable agricultural land.

This paper undertakes to (*a*) describe the current agricultural land situation, focusing on definitional and measurement problems; (*b*) discuss the adequacy of agricultural lands for the 1980s and beyond, where "adequacy" is defined by the standard criterion; and (*c*) explore whether other criteria might be preferred.

The Definitional Morass

An initial task for the NALS staff was to develop a definition of "agricultural land" consistent with its mandate. The mandate was seen to arise out of the nationwide concern about the "loss" of private farmland and from federal, state and local efforts to stop it. The mandate was further perceived as relating almost entirely to the private sector since most farmland is privately owned, and most land use conversions are the result of market decisions. In the final round, the definitions were also influenced by data availability.

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NALS defined agricultural lands as "lands currently used to produce agricultural commodities including forest products, or lands that have the potential for such production. These lands have a favorable combination of soil quality, growing season, moisture supply, size, and accessibility. This definition includes about 590 million acres of land that have no potential for cultivated crop use but are now in agricultural uses, including range, pasture, or forestland" (*Final Report,* p. 21). The measure of agricultural land that NALS adopted was expansive. It includes all nonfederal rural land not actually in "nonagricultural" uses—e.g., rural transportation rights-of-way, water impoundments, or other nonfarm uses. Though chosen in good faith, it is clear in retrospect that both the definition and measure are flawed.

Figure 1 presents the taxonomic breakdown used by NALS. It is based on definitions and statistics from the Soil Conservation Service's, 1977 *National Resource Inventory* (NRI).[1] The first major division in figure 1 is between federal and nonfederal land. This division was seen as consistent with the NALS focus on privately owned lands, since only a minute amount of federal lands is used for crop production (*Final Report,* p. 27).

The next division, "rural" and "urban," is straightforward enough, except for continuing problems of defining and measuring urban lands. Rural land (1,443 million acres), less lands in rural transportation, other nonfarm, and water uses, yields the quantitative NALS measure of agricultural lands (1,361 million acres).

This measure has at least two technical deficiencies as well as a major connotative problem. First, if agricultural commodities are defined to include forestry or grazing output, then the land base is undercounted by half a billion acres of federal lands that contribute importantly to both timber and livestock pro-

[1] In addition to the definitional issue, there are also concerns that quantitative differences among NRI and other source statistics on land use or land use change. There are discussed in McGill, Hidlebaugh, Yovino; Boxley; Brewer and Boxley.

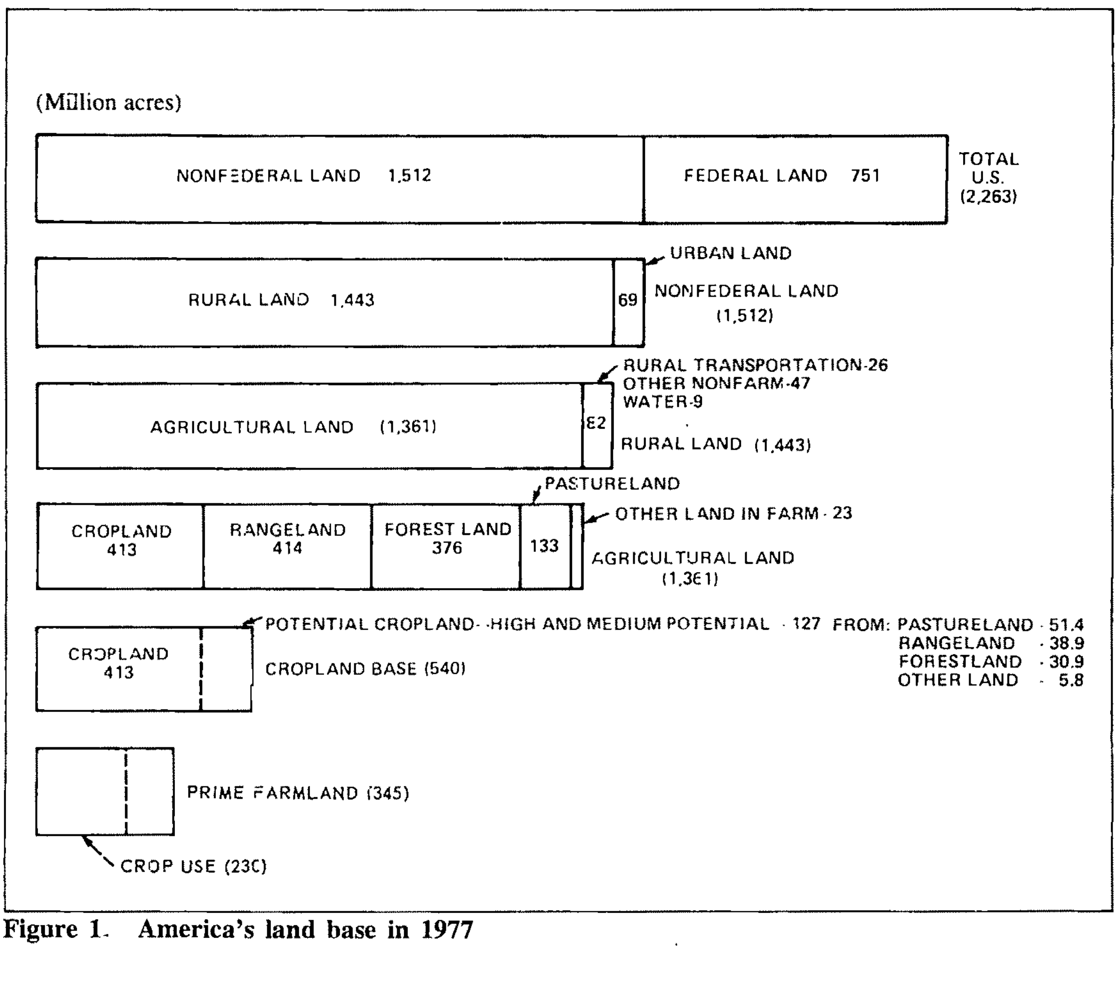

Figure 1. America's land base in 1977

duction.[2] Second, the definition is in part a tautology. Agricultural land, as defined, has to have some minimally favorable combination of soil quality, growing season, and moisture supply; otherwise the land would be barren. But sufficient climatic and soil characteristics to support, however tenuously, a range or forest biome does not necessarily signify economic importance (supramarginal productive capacity), as the last part of the definition implicitly recognizes.

The connotative flaw arises from insufficient distinction between "agricultural land," "cropland," and "farmland," inviting their confusion. Though the *Final Report* avoids equating these different categories, few other reports, including several issued by NALS, observe the distinction. Rarely, if ever, is "farmland" defined.[3] The agriculturalist probably equates "farmland" to the 1.05 billion acres the USDA and census count as "land in farms." For others it might as easily connote the 465 million acres of cropland and cropland pasture enumerated by ERS or the 387 million acres of cropland used for crops in 1980. Clearly—and unfortunately—the *Final Report* does not clarify the babel of tongues about agricultural land.

Although not emphasized, NALS also reported on "prime farmland." Its Agricultural Land Data Sheet includes the 345 million acres of prime farmland enumerated in the 1977 NRI, of which 230 million are cropland. This category is simply defined as "the best land for farming." The ambiguity of the prime farmland concept has been well noted (Woods, Smith and Barrows).

Agricultural Land Conversion

All of the above might be dismissed as hair splitting except for the uses made of the numbers. Two recent sources of statistics on land use change were available to NALS—the 1975 *Potential Cropland Study* (PCS) and the 1977 *National Resource Inventory* (USDA). NALS elected to use the PCS as the source of land use change data, primarily because different enumeration procedures were used in the 1977 inventory (Brewer and Boxley). Data from the PCS indicate that for all categories of what NALS defines as agricultural land, about 3 million acres were converted to nonagricultural uses annually between 1967 and 1975. This formulation poses a "bait-and-switch" problem for the unwary. Almost invariably, the press and the pamphleteers report this as farmland conversion. Lauren Soth, for example, writes: "The government's recent National Agricultural Lands Study found that 3 million acres of farmland are lost to urban developments each year."[4] A more lurid version has it: "In the war between the bulldozer and the plow, one million acres of America's prime farm land are urbanized each year. . . . In addition to the prime land loss, we are losing another two million acres of lesser quality, nevertheless productive, agricultural land to nonagricultural conversion each year" ("Where Have the Farm Lands Gone?" p. 8). Another major paper interprets it as: "The Agricultural Department says conversion of actual and potential cropland to nonfarm use is at the rate of three million acres a year . . . *Wall Street Journal*).

Of the 1.4 billion acres of agricultural land defined by NALS, 856 million acres have either low or zero potential for cropland (268 and 588 million acres, respectively). The PCS estimates that about 675,000 acres of cropland were converted to urban-type uses annually between 1967 and 1975. The conversion of rangeland, forest, or other land in farms with high or medium potential for cropland use was not enumerated separately but is estimated to have been perhaps 200,000 acres annually. Thus, the conversion from the 540 million acres "cropland base" of figure 1 was around 875 thousand acres annually between 1967 and 1975. Since it is these 540 million acres against which questions of future adequacy are judged, the "loss" by conversion should be related to this cropland base rather than the essentially meaningless measure of "agricultural land."

A related and important issue partially explored by the NALS research staff questions the appropriateness of past rates of

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[2] The *Final Report* (p. 27) estimates that about 500 million acres of federally owned land is "agricultural land" (i.e., used for crops, grazing, or forests). It then goes on to ignore this huge quantity of land, saying: "The NALS mandate covers the Nation's entire 1.36 billion acre agricultural land base. . . ." (p. 38).

[3] The following titles provide examples: "Where Have the Farmlands Gone? (NALS pamphlet), "The Protection of Farmland" (a report to the National Agricultural Lands Study from the Regional Science Research Institute), "Disappearing Farmlands" (National Association of Counties Research Foundation) "Land and Food, The Preservation of U.S. Farmland" (American Land Forum).

[4] The author does, however, go on to point out that only 1 million of the 3 million acres are cropland.

change as harbingers of the future (Brewer and Boxley). All the statistics on land conversion were generated in a period that differs substantially from the present; it is unlikely that the pressures for land conversion in the 1980s will remain the same. We anticipate that the 1982 National Resource Inventory will shed light on more recent land use trends.

Potential Cropland

In 1980, the total amount of cropland used for crops (387 million acres) was back at the peak quantity reached in 1949. These are not, of course, identical acres because U.S. agriculture experienced major geographic shifts in the intervening years (Horsfield and Landgren). Nevertheless, if food and fiber demands materialize in the 1980s as projected, we will be moving onto a segment of the supply curve for land for which we have no previous observations.

The only estimates of what the source of new cropland might be are the Soil Conservation Service surveys of 1975 and 1977. The 1977 NRI estimated that the nation had 36 million acres of land with high potential for crop use and 91 million acres with medium potential (fig. 1). The 1975 study found slightly less land with high or medium potential (111 million acres), but the relative proportions of high to medium potential cropland was reversed (Diderickson, Hidlebaugh, Schmude, p. 5). Unfortunately, the price-cost assumptions that went into the construction of these estimates were not well-specified. Building on some initial work by Robert Otte, Fox and Clayton showed that the change in relative proportion of high- to medium-potential cropland for the two years was consistent with the change in the ratio of the index of prices received to the index of prices paid in the years preceding each survey (the ratio was 117 in 1974 and 97 in 1976). Based on these relationships, Fox and Clayton then extrapolated a supply relationship for cropland under five price-cost relationships (p. 74).

These relationships are vague, as Fox and Clayton note, because they are based on neither absolute levels of prices paid or received nor on net farm returns. The point to be made is the paucity of well-founded economic data for estimating future land availability for agricultural production.

Future Land Requirements

Acknowledging the imprecision of measures of supply and uncertainty about flow of agricultural land services, we move on to the demand side of the equation. At the beginning of NALS, several major assessments of future land requirements were underway (notably the program assessments of the Forest Service and the Soil Conservation Service, USDA; the *Global 2000* report; and at Resources for the Future). These assessments were used to prepare baseline projections in an NALS research paper (Boxley). In addition to these projections, the *Final Report* contained year 2000 forecasts of demand growth, crop yields, and planted acreage requirements based on work by O'Brien (p. 52).

These studies defy easy summarization. Suffice to say, the estimates of additional cropland required to meet year 2000 demand projections at constant real prices range from a low of 36 million (Boxley, p. 139) to a high of 113 million acres (*Final Report*, p. 59).

The assessments reviewed reveal the following characteristics:

(*a*) In contrast to projections made in the 1960s and 1970s, recent projections are more expansive in estimating demand growth and more conservative, or at least more hedged, in projecting yield or technology increases. Thus, they are less optimistic, or more "scarcity"-oriented than projections of just a few years earlier. A tendency to weigh the recent past most heavily in projecting the future can be seen clearly. Whether this is a belated, but warranted, adjustment of expectations or an overreaction to the near term remains to be seen.

(*b*) Most of the projections are based on comparative-static, constant-price analysis. The essence of this analytical technique is, first, to calculate the expected future change in commodity demand, given certain assumptions about demand shifters deemed most important (U.S. and world population growth, changes in tastes and preferences, international trade patterns and policies, and, in some models, inflation). Second, the expected growth in supply owing to increased crop yields, productivity, or changing factor combinations of nonland inputs is calculated. Since virtually every future scenario of recent vintage anticipates the rate of demand growth will exceed the rate of yield or productivity increases, land becomes the equilibrating fac-

tor. Thus, the third step of the projection technique is to calculate the change in the land base (net of "losses" to urban or other nonagricultural uses) required to restore equilibrium between the projected quantities demanded and supplied.

This standard methodology has major shortcomings. In a market economy, price is the principal equilibrating mechanism. Only with an infinitely elastic supply of land would the real world track the projection. With a less than infinite elasticity, the process of equilibrium entails movements along the demand and supply curves. As noted above, reliable measures of land supply elasticity are unavailable. It is neither surprising nor inappropriate that predicted land requirements are greeted with distrust.

A further problem with this technique is the burden placed on land as the residual equilibrator and, by implication, as the dominant policy instrument. With respect to the first point, every item in the vectors of demand and supply shifters is subject to uncertainty or vulnerability to change. The comparative-static nature of the model is inadequate for dealing with multiple sources of uncertainty. The power-function nature of possible combinations and permutations of these shifters is inconsistent with the conventional process of constructing scenarios to reflect a range of possible outcomes. To say that the range of possible additional cropland requirements by the year 2000 is between 36 and 113 million acres is unlikely to strike many as a reassuringly precise estimate.

Reliance on land as the equilibrating factor also implies that agricultural land preservation is the most important policy instrument for dealing with questions of adequacy. It clearly is not. The highest estimate of additional cropland likely to be converted to urban use by 2000 is 20 million acres (Boxley, p. 138). A land preservation program that could halve that rate of conversion undoubtedly would be considered highly successful. Yet, the additional output from 10 million acres could alternatively be achieved, for example, with about 0.25% increase in the annual rate of growth of crop yield, as calculated by O'Brien (*Final Report*, p. 59).

If the issue is assurance of adequate productive capacity for the year 2000 and beyond agricultural land preservation programs on aggregate production capacity grounds may be ignoring considerable opportunity costs.

Adequacy of Agricultural Lands for the Future

"Adequate" is an elusive concept. If the question is physical adequacy, then most combinations of numbers (however imprecise) that we have discussed in the previous two sections suggest that we have a physically adequate stock of agricultural lands. But the issue is economic, not physical.

An economically adequate supply may be taken to mean sufficient to meet commodity demands without imposing significant increases on the costs of their production. If this criterion is employed, the question of adequacy of agricultural lands for the future has important normative dimensions: (*a*) The cost criterion implies normative "correctness" of current or traditional production costs. (*b*) Demand growth is normatively unconstrained; supply must rise to satisfy it. (*c*) The choice of a time horizon involves normative as well as technical choices. Failure to deal with these normative matters relegates moral questions to the status of technical issues, increasing the likelihood of conflict over questions of agricultural land adequacy.

Aside from the inevitability of normativism in any discussion of "adequacy," we are impressed by the continuing reoccurrence of the issue.[5] Since the end of World War II, the question of natural resource adequacy has been repeatedly addressed (Lansburg, Fischman, Fisher; Smith). Past experience has consistently been to overestimate demand growth and underestimate supply responses (Heady, p. 4).

Despite the post-World War II record of agricultural surplus and the persistent wrongness of some thirty years of accumulated forecasting experience, the adequacy issue continues to reoccur. Why?[6] And why have the

[5] The question of adequacy of agricultural land in the United States is, of course, only a part of the larger limits-to-growth debate. As Luten notes, the question of limits of growth and optimism and pessimism regarding the human prospect has been debated, without consensus, for a good two hundred years (Luten,

commissions, studies, and conferences failed to lay the issues to rest for more than a short period? Luten, in an interesting article, proposes that the source of the conflict lies in differences between social and natural scientific faiths that cause the former to be eternal optimists and the latter to be pessimists. Luten argues that the optimists believe in their forecasts and wish them to come true and assume that all forecasters, including pessimists, believe and wish similarly. The pessimistic forecaster, however, has the opposite intent: to cause a public to become concerned and to persuade it to change its conduct so as to avoid a bleak future. Differences evident among NALS staff, and in the perspective of the two major sponsoring organizations of the study, would appear to support Luten's hypothesis.

In addition to conflicts in scientific faiths, the National Agricultural Lands Study was subject to another failing: bias toward the national accounting stance and quantifiable objective functions. This bias, common to arguments pressing the case for agricultural land preservation, often leads to oversimplification of complex, multidimensional issues.

In a recent paper Hite and Dillman speak on this issue. They propose that ideology, not economics, is at the root of the agricultural lands protection movement, and "the rigorous quantitative analysis which is the dominant methodological approach of contemporary agricultural economics does not lend itself readily to dealing with questions of values, traditions, and national character" (pp. 3–4).

They continue, observing that "The agricultural land protection issue is not of a single piece of cloth: some of the best, and most universally felt, reasons for protection have little to do with food prices and production efficiency; attempts at rational analysis are confounded by differences in accounting stance (local, regional, national, and world); and some of the arguments having the greatest emotional appeal are based upon extremely weak premises."

of economists to tackle the issue using the same economic model as before but with conviction that this time it will be done "right." Beyond this, however, is the observation that the issue tends to wax following wars, natural disasters or, as in the last case, economic disruptions—which suggests a tendency to overreact or to react with extreme pessimism to bad news. In the case of the OPEC oil embargo of the early 1970s, the dire predictions of a return to preindustrial agriculture clearly did not materialize and the actual adjustments within the agricultural sector have been more moderate than many predicted (Heady).

In addition to national or global concerns about adequate food supplies, Hite and Dillman enumerate six reasons for land retention programs frequently put forward at the local level.[7] Three of these reasons (local self-sufficiency, production dispersion, and preservation of specialized agriculture) require national accounting stance for validity. The standard economic model, however, cannot address these issues and seldom provides support for local planners who would argue them.

Are There Better Procedures?

We do not have a comprehensive procedure for bridging the gap between the social and biological science perspectives as identified by Luten or for addressing the ideological issues raised by Hite and Dillman. In reflecting on the National Agricultural Lands Study, however, we offer three proposals we think could at least advance rational debate in the next iteration, which is sure to come.

Assess Carefully the Irreversibility of Land Use Change

In 1964, Ciriacy-Wantrup wrote about the "problem of irreversibility" in relation to projections of future social needs. He proposed a land-use strategy based on a "safe minimum standard" of present performance specified in such a way that maximum possible future losses are avoided (p. 257). Wantrup likened his proposal to an insurance policy against serious losses that resist quantitative measurement. Rather than maximizing some quantifiable net gain, the objective is to choose premium payments and benefits in such a way that maximum possible losses are minimized. Two dimensions of Wantrup's formulation are pertinent: (*a*) the existence of an irreversibility that makes conversion a present issue for land policy, and (*b*) the balance of program costs and benefits.

Without disputing its existence, we feel the irreversibility of land conversion has been accepted too uncritically. The common practice

[7] They are: (*a*) protection of agriculture as an important local industry; (*b*) maintain local food supplies or self-sufficiency; (*c*) provide dispersion of food production to prevent national food shortages; (*d*) preserve specialized soils and climatic zones; (*e*) provide open space, recreation, wildlife habitat, air and water recharge capacity, and aesthetics; and (*f*) promote orderly growth of urban areas.

has been to consider all conversions of land to nonagricultural uses as irreversible, and, by implication, to equate "irreversible" with "irreplaceable."[8]

"Irreversibility" has both physical and economic dimensions. Where true physical irreversibility threatens, then the relevant issue would appear to be "replaceability." Although the existence of unique agricultural microclimes are asserted to exist (tart cherry orchards on Grand Traverse Bay, Michigan, artichokes in California) these would appear to be sufficiently rare and localized to warrant individual treatment under a regional or state accounting stance.

Economic reversibility rightfully involves changes in land use at some future time. This requires a complete economic accounting of the discounted flow of income during the intervening years of the converted use as well as the discounted cost of future reconversion. If the issue is seen as a loss of "critical mass" or "agricultural infrastructure," an economic accounting is obligated to consider and weigh the cost of prospective future obsolescence of the present infrastructure against the cost (and efficiency) of building a new infrastructure when it becomes needed.

It may be that careful examination might warrant the conclusion that for all practical purposes the loss of any land to U.S. agriculture is irreversible, as the NALS *Final Report* asserts. The point is that cropland irreversibility is a quantifiable concept that does not have to rest on assertion. One irony of the land preservation drive is that society, in seeking to prevent land conversion by removing certain rights of ownership, may in fact create institutional or legal barriers that will prove truly irreversible, even into perpetuity.

Gauge the Opportunity Costs of Agricultural Land Preservation

Another aspect of Wantrup's "safe minimum standard" strategy is the weighing of future benefit and cost streams. He considered California irrigated agriculture and identified as "insurance premium" the higher construction costs necessitated if urban-industrial development is diverted from the alluvial plains to the benches, foothills, or otherwise inferior locations. Wantrup concludes: "There is, however, some evidence that, in balance, the costs are not too high and are likely to decrease in the future" (p. 259).

Seventeen years later Hite and Dillman returned to the same theme in another area. Asserting that "our efforts as agricultural economists should be focused not so much on attempts to estimate the benefits to such land preservation as on attempts to estimate its costs" (p. 17), they cite a study by Cousins of the cost of resorting to second-best industrial sites in the Greenville-Spartanburg (S.C.) SMSA. Their comments are worth quoting directly:

> To our knowledge, however, his are the only numbers we have of what the opportunity costs of preserving prime agricultural lands might be, and if they are at all indicative of such costs, they suggest to us that the price tag on protecting prime lands will not be low. Indeed, the agricultural use-value, estimated by discounting present net farm income, in perpetuity, of all the prime lands in Greenville County now occupied by industrial plants is only about 8 percent of the minimum added site-preparation costs that would have been forced upon the industries if they had been required to resort to non-prime sites. Before the nation or any locality embarks upon an extensive agricultural lands preservation program, agricultural economists would seem to have an obligation to determine what the opportunity costs are likely to be and make certain the decision makers can gauge just how much prime land they can afford to protect. (Hite and Dillman, p. 18–19)

Recognize Limitations of Statistical Measures and the Ability to Track Changes

In Luten's discussion of the Malthusean corollary, he observes that under conditions of compounded growth, it makes little difference how accurate the estimates of resource magnitude are; scarcity is rarely remote and it comes abruptly (p. 139). He makes the point by retelling the riddle of the lily pond. The pond's open water represents remaining natural resources. Assume exponential growth (so that the water lilies, if unchecked, will cover the pond in thirty days) and that one can estimate the magnitude of open water only to within 10 percent (a generous estimate, Luten believes, of attainable precision for measuring natural resource stocks). For 25 days, open water will not diminish within our ability to measure it with certainty; its value remains at 100 percent. Only on the 26th day does growth

[8] For example, the executive summary of the NALS *Final Report* says: "The United States has been converting agricultural land to nonagricultural uses at the rate of about three million acres per year. . . . For practical purposes, the loss of this resource to U.S. agriculture is irreversible."

approach measurement error (93.75% remaining open water). On day 27, 87.5% remains; on day 28, 75%. Clearly something is happening! On day 29, perhaps it becomes clear that there is a need to deal with the growth, but there is no reason to panic; after all the pond still has half of all the open water it ever had (p. 147).

In a less catastrophic sense, we feel the parable may have applications to the question of agricultural lands adequacy. Citizens who observe what is happening to rural land around them also are aware that similar phenomena are occurring elsewhere. How accurately are we tracking the aggregate effect of all of the disaggregated land-use decisions? Are the SCS statistics on urban land for 1958, 1967, 1975, and 1977 correct, or are we observing only measurement errors? One strong impression that we carry from the National Agricultural Lands Study is the need to improve the nation's systems for inventorying and monitoring natural resources.

Objective Inquiry in Adversarial Settings

The NALS raises important issues of process as well as fact. Can special analyses of agricultural land adequacy, or other controversial policy issues, be assured of objectivity? Many interested parties have a stake in the conclusions and recommendations of such inquiry. Payoff can be in the form of expanded bureaucratic turf, larger budgets for particular agencies, public sanction of particular tools for constraining local development, reduced taxes on rural properties, or personal enhancement. Absent a strong and neutral oversight body to shield researchers and assure that professional procedures are followed, their work is vulnerable to influence, to misrepresentation in the public media, or to being withheld entirely from the public.

Should this occur, the tradition of science is to wait until the work of scientists and scholars elsewhere erodes the credibility of those accounts. When there is momentum for political action, this process may take too long. Misguided policies, programs, or executive orders may result. Procedures for immediate repudiation are less well-established. Absent effective quality control of accounts of scientific inquiry, a loss of public confidence will rob science of its ability to guide public decisions. No short-run payoff can compensate for such a loss of national steerage.

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On the Power of Macroeconomic Linkages to Explain Events in U.S. Agriculture: Discussion

Robert L. Thompson

I am very pleased to see a paper on the macroeconomic setting of agriculture in the 1980s on the program. We agricultural economists tended to take a provincial sectoral or partial equilibrium view of the world until events of the early 1970s forced us to recognize that there exist some strong linkages between the agricultural sector and the rest of the economy. We found that agriculture's small percentage of the gross national product (GNP) generated, and of the labor force employed, did not qualify it for such partial equilibrium treatment after all. Macroeconomists discovered at about the same time that they needed to worry about agriculture. At the time this was realized, no macromodel contained a simultaneous agricultural component, and no agricultural sector model contained simultaneous links to the macroeconomy except through deflated prices.

Gardner's paper contains basically three parts: (*a*) a review of the growing theoretical and empirical literature on the links between agriculture and the rest of the economy, (*b*) some original empirical analysis on the subject, and (*c*) some conclusions and implications concerning forecasting in the 1980s. I will comment briefly on each of the three sections.

Gardner's literature survey contains a useful and fairly complete catalog of the literature which has begun to grow quite rapidly in this area over the past decade. It reveals that much of the work done to date on the interrelations between agriculture and the rest of the economy has had ad hoc theoretical foundations for those hypothesized relationships which in turn have been confronted with data. Agricultural economists who began working in this area of "sectoral macroeconomics" were frustrated when they turned back to their macroeconomic theory to find that it dealt only with a composite aggregate real output of the economy, Y, and aggregate price level, P. Any differential sector impacts of shocks to the system were assumed away. Unfortunately, Gardner's list of theoretical transmission mechanisms that may generate differential effects across sectors is rather short. One alternative would be that of Shei, who has taken a monetary approach to the links between agriculture and the rest of the economy, focusing on differences in marginal propensities to absorb goods from different sectors. This causes differential effects across sectors as consumers attempt to adjust existing real balances toward desired real balances in response to a shock to the system. This is but one possible alternative, and much more is clearly needed to provide more secure underpinnings for empirical work in the area.

In reviewing the existing empirical work, I agree with Gardner that much of the empirical evidence is not strong, and that the same data, appropriately massaged, can support contradictory hypotheses. We clearly have far to go in this regard. The empirical work (i.e., the regression analysis) presented in this paper does provide some interesting perspectives. Nevertheless, the specification and estimation of such single-equation regression "models" without fully specifying an underlying structural model leaves me uneasy. It is not clear to me why "it seems unnecessary to strive for a fully specified model." Without this, the specification ends up quite ad hoc, and the basis for including or excluding certain variables is not clear.

More problematical is the failure to clearly define the hypothesized lines of causality, and to delineate clearly which variables are exogenous and which are simultaneously determined with the dependent variable in the re-

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gression. To me, at least, it is not attractive to refer to inflation or recession as exerting a causal influence on agricultural prices. Agricultural prices are a component of the general price level and are simultaneously determined with all other components. Both respond to shocks to the system such as a change in the money supply.

If one wishes to estimate the reduced-form equation for one endogenous variable, its correct specification is clear after specifying the structural model. This also would help avoid having to resort to terms like "quasi-exogenous." It is not clear to me that all variables on the right-hand side are sufficiently exogenous to apply OLS regression in this case. Before the present approach is followed, it would at least be desirable, following Sims, to apply the available tests of exogeneity rather than assuming that all right-hand side variables are at least quasi-exogenous.

A couple other points which need to be made concerning the empirical analysis:

(*a*) The quasi-stepwise regression procedure in tables 2 and 3 is not terribly appealing. If there is such a thing as a "correct" conceptual model underlying the specification, all but one of these sets of results suffers from specification error and their coefficient estimates should be biased.

(*b*) In deriving his measure of "anticipated inflation," Gardner assumes "quasi-rational expections," to use Nerlove's term, on the part of consumers and employs an ARIMA model to generate his measure of anticipated inflation. However, there do exist survey data collected by Livingston (see Carlson) on actual inflationary expectations which could have been used. This would have avoided having to make any assumptions about economic agent's rationality or quasi-rationality in their formulation of inflationary expectations.

While Gardner's results provide some interesting insights, I would make a plea for more structural modeling of the interactions between sectors including monetary linkages. Two recent theses—by Shei at Purdue and Hughes at Texas A&M—have made starts at general equilibrium modeling of these linkages. Shei's work emphasized monetary linkages and Hughes', the financial market linkages. Much more needs to be done.

Finally, turning to Gardner's conclusions and implications for the 1980s, I do not find the evidence nearly as compelling as he does that the classical dichotomy between real and nominal prices holds. There are very good reasons, as he points out early in the paper, to expect the effects of monetary shocks on prices to be nonneutral across sectors, at least in the short run. As Bordo has pointed out, the necessary conditions for neutrality to hold are stringent. "If monetary changes were perfectly anticipated—and if all prices were perfectly flexible and we were to ignore distribution effects . . . *as well as* the effect that the expected rate of inflation will have on the real rate of interest and on cash intensive relative to other goods . . .—then, the introduction of new money would not produce any 'real' effects" (p. 1089). Furthermore, Barnett recently applied several causality tests to the relation between money supply and the ratio of food to nonfood components of the CPI. His results showed a significant positive causal link from money to relative prices with a five-month lag. No causality ran the other way (p. 108). He also found strong causal links running from money supply to nominal agricultural prices and none the other way. This goes against those who argue that the inflationary effect of real shocks, such as a crop failure comes from *ex post* validation of the resulting price increase by the monetary authority.

From the available evidence, I reach the opposite conclusion from Gardner—that if we utilize agricultural sector models which are fit with deflated prices to project real agricultural prices and then apply separate projections of the overall rate of inflation to "reflate" those values, we are destined to miss the mark in our nominal price forecasts. Moreover, results such as those of Barnett cited above suggest that there are some potentially serious problems with deflating our data series to "remove the effects of inflation" when doing econometric modèling, for example. If monetary shocks affect nominal prices differently, the analyst may actually be perverting the data series by deflating by a price index, thereby biasing the coefficients estimated from such series.

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Agricultural Land: Adequacy of Acres, Concepts, and Information: Discussion

Philip M. Raup

The approach taken in the National Agricultural Lands Study to the question of the adequacy of agricultural land is full of hidden agendas. Little wonder that the conduct of the study generated sharply conflicting interpretations of past trends and future prospects. Brewer and Boxley's (hereafter BB) report from the trenches of that conflict gains value from its immediacy and invites reflection upon some of the unresolved issues that haunted the study from the beginning.

A primary concern emerges from the evident inadequacy of statistical data on shifts in land use. This is illustrated by continuing confusion in the interpretation of land use data when classified as "rural," "agricultural," "farmland," and "cropland."

The NALS *Final Report* (p. 2) says "the most recent available data show that about 3 million acres of agricultural land are converted each year to urban and built-up uses—of this 3 million acres an estimated 675,000 acres is from the 413 million acres classified as existing cropland."

These data for 1967–75 come from the *Potential Cropland Study,* published in 1977 by the USDA. That study does not call the 3 million acres "agricultural land." Instead, it refers to the converted acres as "rural" land. This improper use of "agricultural land" to characterize rural land is repeated on p. 13 and in table 5 of the NALS *Final Report.* The correct figures (from the *Potential Cropland Study*) are again cited in the text, but the incorrect use of the designation "agricultural land" is retained throughout the *Final Report.*

Since the figure of 3 million acres lost to agriculture annually has acquired widespread currency, it is important to set the record straight. Table 1 shows that the (nearly) 3 million acres converted annually were "rural" lands, of which 30% was not "agricultural." Only 23% (683,000 acres) came from "cropland," and of that, only 606,000 acres (21% of the total) were converted to urban use. The National Agricultural Lands Study has introduced confusion when it could have promoted clarity in interpreting admittedly deficient land-use data. BB treat this issue, but they could have been more emphatic in stressing the extent to which cropland losses have been overstated by a media and agency preference for shocking statistics. We are not losing 3 million acres of farmland annually, as the media now almost universally report.

A further distortion imbedded in the NALS data that BB analyze grows out of confusion between the physical and the economic supply of land. Data on physical supply are given economic interpretation by the use of current prices and this generation's tastes and preferences. These time-specific data then become the basis for long-run projections. The effect is to freeze the supply of land in terms of current patterns of use. This is contrary to all historical evidence.

This view of the land base has been reinforced by the analytical procedures used to project the demand for land. Most of the discussion of the adequacy of agricultural land has drawn upon partial equilibrium analysis for its theoretical support. Much of the argument in favor of policy measures to preserve agricultural land also reflects a Ricardian view of the "natural and indestructible powers of the soil." In this view, the supply schedule for agricultural land is fixed. In conventional economic graphics, it is a vertical line, unresponsive with respect to price.

The significance of the distinction between a physical and an economic concept of land availability is suggested by the following quotation from the NALS *Final Report.* "There are nearly 14 million acres of prime land in the Northeast, more than in either the eight Mountain states or five Pacific Region states" (p. 20).

Note the likely influence of proximity to markets, accessibility, and related cultural

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Table 1. Summary of Estimated Conversion of Rural Land in the United States to Urban and Water Uses, 1967–75

	Purpose of Conversion								
	Urban Uses			Water Uses			Total Conversion to Urban and Water Uses		
Land Use before Conversion	Total (Acres)	Average Per Year (Acres)	Per-centage	Total (Acres)	Average Per Year (Acres)	Per-centage	Total (Acres)	Average Per Year (Acres)	Per-centage
Cropland	4,846,473	605,809	29.1[a]	617,636	77,204	9.2	5,464,109	683,014	23.4
Pasture, range	3,210,542	401,318	19.3	1,111,535	138,942	16.6	4,322,077	540,260	18.5
Forest	4,422,411	552,801	26.6	2,152,205	269,026	32.1	6,574,616	821,827	28.2
Other land	4,156.187	519,523	25.0	2,827,362	353,420	42.1	6,983,549	872,944	29.2
Total conversion	16,635,613	2,079,452	100.0	6,708,738	838,592	100.0	23,344,351	2,918,044	100.0

Source: Computed from *Potential Cropland Study*, appendix table 2a, p. 16.
[a] Cropland converted to urban uses as percentage of total conversion: 20.8.

characteristics in the definition of "prime" land. This points up the fact that projections of land requirements must be based on economic weights which in turn are the determinants of what is "agricultural land," "farmland," or "prime land." These are cultural concepts, and they have been remarkably prone to change.

The most portentious assumption on which the NALS rests, and on which I would have welcomed more discussion from BB, is the assumption of constant real prices for food in all projections. This assumption loads the dice. There can be no meaningful economic projection of land requirements if price is assumed to have no effect upon the economic supply of land.

The assumption of constant real prices for food forces all adjustment in supply and demand onto the supply side. This is supply-side economics with a vengeance. The assumption also implicitly involves a continuation of the present consumption mix, as well. These two assumptions preclude any adjustments to land shortages by shifts in the demand for food. This seems highly unrealistic.

The possibility of adjustments on the demand side is discussed briefly on pages 44–46 of the NALS *Final Report*, but no quantitative estimates are made. In effect, demand is treated as an exogenous variable.

A concluding lesson imbedded in this battle dispatch from BB can be posed as a question: Should researchers take into account the fact that publicists want to report shocking statistics? If the statistic is unremarkable, there is no story. In the same vein, political leaders like to scare people. Fear is apparently a more effective motivation than reason.

This is augmented by the growth of the "hunger business." We have a number of organizations that were created to fight hunger. The mission of these organizations, and the jobs of the individuals involved, depends on finding hunger or the threat of hunger. These forces create an information-disbursing system that rewards exaggeration of any threat to food supplies.

BB make no reference to the fact that the majority of the U.S. population is now remote from biological processes. The percentage of the population without any direct contact with agriculture or food production has followed an exponential growth pattern that parallels the lily pond example. We have suddenly generated a population that does not understand the system by which food is produced and can be

panicked by threats of scarcity. This is the background to the National Agricultural Lands Study.

It is regrettable that these hype-oriented pressures for spectacular statistics have obscured the real problems associated with growing competition for agricultural lands. In seeking to dramatize the problem, the NALS has weakened the credibility of nationally funded research undertakings. This seems to be the main lesson to be read out of the Brewer-Boxley paper.

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Commercial Agriculture in Historical Perspective

W. W. McPherson and Max R. Langham

Achievement is a pleasant spectacle when it has been made in spite of obstacles.
—Edwin Ware Hullinger

Our session title suggests that agriculture in the "Old South" can be treated as an entity.[1] To do so requires such great generalization that one soon realizes that much of what is said about modern agriculture in the South can be said about other agricultural regions of the United States. That is as it should be since forces from our political economy which induce adjustment in southern agriculture are also those which affect all agriculture.

Unique features of the "Old South" include the purpose and organization of the initial settlements by Europeans and the influence of these features on subsequent developments. Initial settlements employed systems of indentured servants and slaves to produce products for export to Europe. These features have made the adjustment problems in the South somewhat different and probably more difficult than those elsewhere.

We consider the "Old South" to include those areas in which the slavery system prevailed prior to the Civil War. It includes most of the states of Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, Arkansas, Tennessee, and Kentucky. Parts of Maryland, northern Florida, eastern Texas, and central Missouri were in the Old South, but are excluded here for we are working with data at the state level. For convenience, we have also used regional data as reported for three of the USDA Farm Production Regions—Appalachian (West Virginia, Virginia, North Carolina, Kentucky, and Tennessee), Southeast (Alabama, Georgia, South Carolina, Florida), and Delta States (Arkansas, Louisiana, and Mississippi).

We begin with an historical sketch of the Old South to provide a background of how southern agriculture has been transformed from early settlements until the 1940s. We then look at post-World War II changes and conclude with some speculation about the future.

Early Settlement

Attempts to colonize the South in the seventeenth century were for the purpose of producing products for export to Europe—rice, indigo, tobacco, forest products, and cotton. "The typical institutions—servitude, slavery, the plantation system, and the credit system—were not peculiar to the South nor established by the English race" (Gray, p. 301). Throughout the West Indies, Central America, and South America, the French, Spanish, Dutch, and Portuguese nations engaged in the establishment of similar economic enterprises under similar institutional systems. According to Gray (p. 341), these enterprises were in part the outgrowth of nationalistic ambitions but were promoted and made possible by investors from the nobility, gentry, and bourgeoisie who were essentially interested in deriving profits from investments. But, these colonial enterprises were unprofit-

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[1] Such works as Nicholls, and Strand and Heady, and USDA publications, *Farm Costs and Returns* and *Economic Indicators of the Farm Sector*, reveal the inter- and intrastate complexity of the agriculture of a region that extends across states.

able largely because of unfamiliarity with this new environment and difficulties of communication and administration from across the Atlantic.

Land settlement for profit was then attempted by subordinate associations of capitalists. This approach failed also and private plantations followed. These private enterprises "had the advantage of experience with the new environment and the opportunity in some cases to acquire at small cost the lands, improvements, and equipment of unsuccessful colonizing agencies. With the development of regular trade, the planter was provided not only with market outlets for his products, but also a means of procuring on credit the requisite servants, slaves, and equipment" (Gray, p. 341).

Farming Systems and Agricultural Growth to the 1860s

Traditional farm enterprises included cotton, a dominant crop throughout the Old South; tobacco in Virginia, the Carolinas, and parts of Kentucky and Tennessee; rice in South Carolina and Georgia; and sugarcane in Louisiana. Cotton and tobacco were the major exports. Corn was the major subsistence crop—it was the primary feed for work animals and subsistence livestock and was widely consumed for food. These crops were highly labor-intensive. Estimates of the annual man hours per acre for about 1800 and 1840, respectively, are as follows: cotton, 184 and 135, and corn, 86 and 69 (McElroy, Hecht, Gavett, p. 3). The use of slaves was a system in which landowners were able to acquire labor for working areas in excess of what the owner's family could cultivate. Hired labor was not a feasible alternative since moving to the frontier and working one's own land was an option for free persons.

In 1850, the ten states that we include in the Old South contained 34% of the total population and 91% of the slaves in the United States (U.S. Census Office, p. 248). The U.S. population was 14% slaves compared to 37% in the Old South. Among the ten states, slaves as a percentage of total state populations ranged from 22% in Kentucky to 58% in South Carolina.

Labor, obviously, was the limiting factor of production during this era. The acquisition of additional slaves was a means of rapidly expanding commercial output for export to Europe so long as additional lands were available. By 1860, westward expansion of cotton production had moved well into Texas and Missouri. While growth in output and wealth was taking place, the degree of inequality of income distribution also was increasing because slaveholders were able to expropriate any surplus over bare subsistence produced by the slaves. Ransom and Sutch (p. 4) estimated that the distribution of output on large slave plantations in 1859 was as follows: interest and depreciation on capital, 7.7%; salary of management, 3.4%; land rent, 35.7%; food, clothing, etc. for slaves, 21.7%; and expropriation by slave owner, 31.5%.

Two farm organizational systems were in operation: (*a*) the small one-family farm on which the operator and his family provided most of the labor, and (*b*) the plantation on which labor was provided by slaves. There was a wide range in the sizes of farms worked by slaves, from those with a few slaves to those with hundreds. One-family farms occupied the less productive lands and had poorer access to the infrastructure, such as transportation, communication, and education. They were largely self-sufficient with small quantities of output sold to meet low cash expenses.

The number of slaveholders (319,143) was equal to 60% of the total number of farms (534,800) in 1860. However, the distribution of slaves among slaveholders was highly skewed. About 50% of the slaveholders owned five or fewer slaves each and, as a group, 10% of the total number of slaves. At the other size extreme, 1% of the slaveholders also held 10% of the slaves.

There have been several attempts to measure the economies of scale in cotton production during the slavery period. (See, for example, Ransom and Sutch, pp. 73–78, and Gray, pp. 462–80.) There is no reason to believe that economies of scale existed beyond very small levels of production at the farm level, for only simple hand and animal implements were used. Economies in ginning would occur up to the capacity of a gin unit, and possibly in marketing and financing up to rather large outputs. However, the main factor that contributed to the growth of the plantation system was the ability of the landowner-decision maker to expropriate the surplus produced by slave labor.

The main technological factor that influenced agriculture in the Old South prior to

the Civil War was the invention of the cotton gin in 1793, which reduced processing cost dramatically and increased farm-level demand. This event occurred at a time when the prices of rice, tobacco, and indigo were declining and plantations were facing serious difficulties. In 1793, the South produced 10 thousand bales of cotton and exported 4 thousand; in 1810 production had increased to 178 thousand bales and 124 thousand were exported (Vance, p. 42). Production of cotton in 1860 was 3.8 million bales. These rather amazing increases in production were accomplished by employing more labor and traditional inputs on additional acreages of land. Of total U.S. production in 1860, the Old South produced about 90% of the cotton, 100% of the rice, 72% of the tobacco, and 100% of the sugarcane. Thus the Old South was export-oriented throughout the slavery era. International forces were also operating on the input side as capital markets were based largely in England.

Sharecropping Era, 1860s to 1940s

Immediately following the Civil War, plantation owners attempted to reestablish operations by hiring freedmen for wages.[2] However, low cotton prices (due to a release of cotton stored during the war) and serious droughts in 1866 and 1867 resulted in a sharp drop in wages paid. These decreases in wages ranged from 7% in South Carolina, where wages were lowest, to nearly 40% in Mississippi (Ransom and Sutch, p. 65). Plantation owners and hired workers were displeased with the wage labor system and it was very rapidly replaced by the sharecropping system—a system in which both landowner and sharecropper had a vested interest in seeing the crop through the harvest. By 1880 only 9% of the agricultural land in crops in the Cotton South was cultivated in units that could be considered plantations worked with hired labor (Ransom and Sutch, p. 87).

Ransom and Sutch (p. 7) estimated that, on the average, a slave who became a sharecropper had an increase in welfare of 80% to 105%

provided an opportunity for "poor whites" to work on the better lands of the plantations. Apparently this opportunity was a superior alternative for many white families. In 1935, there were 368,406 black sharecroppers and 347,846 white sharecroppers in the whole South. In the Old South, there were 338,000 black sharecroppers and 279,000 white sharecroppers. The black sharecroppers accounted for 48% of farms operated by blacks and 14% of all farms in these states. The white sharecroppers accounted for 16% of all farms operated by whites and 11% of all farms. All tenant classes included 45% of the whites and 79% of the nonwhites.

Social status was identified with land tenure status, from lowest to highest: hired laborer, sharecropper, share tenant, cash tenant, and landowner, and among landowners social status varied directly with acreage owned.

The sharecropping system reached a peak in the early 1930s and began to decline rather rapidly in the late 1930s. From 1935 to 1940, the number of white sharecroppers declined 25% and nonwhites 17% as migration from farm to nonfarm employment accelerated. This labor adjustment was due to acreage allotments on cotton, tobacco, and peanuts—major crops in the sharecropping system—and to increasing off-farm opportunities.

In 1940 there were nearly 22 thousand plantations (defined as multiple-farm units on which 5 or more farm families, including at least 1 cropper or tenant family, are regularly employed), containing 242 thousand farm units—11% of all farms (U.S. Dep. of Commerce, 1940). These farms produced 28% of the cotton harvested. Also, 42% of all farms were classified as subsistence farms—defined as farms on which production for home use was the major source of income. In the remainder of the United States, 27% of the farms were in the subsistence category.

Throughout the sharecropping period, the land per farm family changed very little. The production systems for traditional crops of cotton, tobacco, and peanuts for cash and corn for subsistence were essentially ones in which inputs were combined in fixed proportions of labor, land, mules, plows, hoes, and other traditional inputs. The number of mules in the Old South began to decline after 1935

substitution of tractor power. The introduction of tractor power in cotton and tobacco production lagged behind its use in grain production. Peak manpower loads in the production of cotton and tobacco occurred during harvesting and, in the early stages of mechanization, tractor equipment that would substitute for manpower in harvesting was not developed. Also real labor costs, related to the social constraints on the outmigration of blacks (especially discrimination in education and lack of acceptance in many occupations), lagged in the Old South. The Old South had only 7% of all farm tractors in 1930 and 6.3% in 1940. However, by the early 1940s farm wage rates were beginning to rise faster than other costs as the migration of workers from sharecropper and other tenant families accelerated.

With the deterioration in soil fertility under continuous row cropping, the use of chemical fertilizers was an important factor. From 1932 to 1937, 51% to 58% of the commercial fertilizer used in the United States was applied on farms in the Old South.

Cotton acreage and production reached a peak in the United States and in the Old South in the period 1926 to 1930. This region's share of acreage and production between 1911–15 to 1926–30 dropped from 57% to 48% and from 63% to 57%, respectively. The most rapid increases occurred in new areas of Texas, Oklahoma, and Missouri. The Old South's shares increased in 1935–40 as a result of the historical base used to calculate acreage allotments under the agricultural adjustment program. At the same time, the expansion of cotton acreage in California and Arizona was getting underway.

Five-year average yields of lint-cotton fluctuated from a high of 201 pounds per acre in 1911–15 to a low of 151 pounds in 1921–25. Soil erosion and the boll weevil and later the pink boll worm were major factors that affected yields. The boll weevil entered Texas in 1892; by 1903 it had spread over most of Texas to the Louisiana border; by 1912 it had crossed Oklahoma, Arkansas, Mississippi and was halfway into Alabama, and by 1922 it covered the entire southern cotton belt (Ransom and Sutch, p. 173). In Louisiana, Mississippi, Alabama, Georgia, and South Carolina, the averages of the first four years after infestation compared to the four years before infestation showed reductions of 27.4% in acreage and 31.3% in yield (Ransom and Sutch, p. 175).

Cotton prices were highly influenced by the international market and there were wide fluctuations. Exports that reached a peak of 10.9 million bales in 1927 dropped to 3.3 million in 1939. The 1930–34 price of cotton was 51% of 1925–29. The price of food grains, which dropped by 50%, was the only price that fell relatively more than the price of cotton. Thus it should not be surprising that the cotton and wheat areas were able to achieve a unification in political support—they had many problems in common, such as being heavily dependent on the export market, low prices and subsequent accumulation of large carryover stocks. In 1939, the carryover of cotton exceeded annual production for the first time in history.

Tobacco was second to cotton in terms of cash income produced in the South. Although the average U.S. acreage of tobacco was only 4% of that for cotton in 1926–30, the farm value of tobacco was 22% of that for cotton. In the Old South the income from tobacco relative to cotton increased from 17% in 1911–15 to 32% in 1926–30 and to 61% in 1935–40. Soil conditions for tobacco are more restrictive than for cotton; the Old South production was concentrated in the Atlantic Coastal Plain and the Appalachian areas. North Carolina and Kentucky continuously produced about 70% of the farm value of tobacco from the Old South, but their shares have changed because of the increased demand for cigarettes relative to other uses of tobacco. In 1911–15, Kentucky produced 43% and North Carolina 28%; in 1935–40, North Carolina produced 48% and Kentucky 23%. Acreage of tobacco harvested increased in all but one five-year period from the Civil War until 1926–30. Subsequently, acreage was reduced by allotments. There is no indication of a trend in yield per acre until the reduction in acreage in the 1930s.

Sugarcane production was essentially limited to Louisiana until the late 1920s when production was started in Florida. Production increased consistently from the Civil War until 1898; thereafter there were wide fluctuations. The peak year between 1870 and 1935 was in 1904 with 803 million pounds of raw sugar, and the low year was 1926 with 96 million pounds.

Soil, water, and temperature requirements limited rice, another one of the early settlement crops, to a rather small geographic area. Early commercial production was mostly in South Carolina and Georgia. By 1890, Louisiana had surpassed South Carolina as the leading rice-producing state. Subsequently, as cotton became more competitive, rice production

moved out of South Carolina and Georgia and expanded in Arkansas and Texas (Holder and Grant, pp. 1–3).

Peanuts is a more recent cash crop of importance in the Old South. In 1933–42, there was an annual average of 3.0 million acres planted in the United States, of which 1.1 million were picked and threshed. Eighty-three percent of the total acreage and 89% of the picked and threshed acreage were in the Old South; the remainder was in Texas and Oklahoma.

In summary, the early agriculture of the South was based on trade. Indeed, plantation agriculture would never have developed without a strong European demand for tobacco, indigo, and cotton. Between 1910–14 and 1936–40, the value of cotton and tobacco exports ranged from 48% of the U.S. total agricultural exports in 1921–24 to 66% in 1936–40. In 1905–09, 65% of the cotton production was exported. This quantity dropped to 40% in 1935–39.

Economic forces combined so that agriculture in the Old South expanded rather continuously from the Civil War until the late 1920s. In the 1930s, in the face of reduced exports and low prices, the Agricultural Adjustment Administration (AAA) played a major role in the reduction of acreages.

In the next section we look at agriculture in the modern South. There are indications that the South's, and indeed U.S., agriculture will again face greater dependence on international forces and greater risks.

Modern Era, 1940s to Present

During the last of the 1930s through the 1960s, the Old South and the producers of the "basic" commodities (cotton, tobacco, peanuts, and grains) elsewhere in the United States were somewhat insulated from the international markets via price supports and acreage allotments. There was an acceleration in changes, especially in the Old South. With the development of mechanical power and equipment for all operations from land preparation through harvesting, chemical weed control, and decreased supplies and increased costs of labor in agriculture, sharecropping as an institutional arrangement and source of labor and mules as a source of power disappeared in the late 1950s and early 1960s. Thus the Old South essentially disappeared.

Number and Size of Farms

The number of farms in the South has decreased more rapidly than in any other major region of the United States. During the period 1950–60, the South lost 40% of its farms. From 1960 to 1970, it lost 48% of those remaining (U.S. Dep. of Commerce, 1980, p. 688). By 1980 there were 626,500 farms in the 10 states of the Old South, with an average farm size of 203 acres. This size compares to 244 for the Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio).

During the five years 1974–78, farms with sales of under $2,500 decreased in number in contrast with the rest of the United States. The largest size group (sales above $100,000) increased 48% and the $2,500–$9,999 group increased 19%. The data suggest a growing bimodal distribution of sizes in both the United States and the South. The lower peak of the bimodal distribution seems to be forming at somewhat higher sales levels in the South in contrast to the rest of the nation. The categories are consistent with a pattern of small, part-time farms supplemented with off-farm income and large, full-time farms. This pattern is also consistent with the trend of more farm family income coming from nonfarm sources—52% during the 1974–79 period compared with 31% in 1950 for the United States.

Inputs

The basic trends in input use in the South cannot be distinguished from the rest of the nation or, for example, the Corn Belt. Nonpurchased inputs (mainly land and labor) have declined sharply relative to purchased inputs. The purchased inputs increased as capital in the form of equipment has been substituted for labor, and improved seeds, fertilizer, and pesticides have been substituted for land. The index of interest payable per acre in U.S. agriculture has increased thirtyfold since 1945, sixfold since 1967. Some of the increase is due to increased interest rates but most is associated with increased capital use.

Fertilizer use per acre (especially nitrogen) in the three-region South has been heavier than in most other agricultural regions (USDA 1981a). This use is associated with high valued crops and older, more marginal soils. The agriculture of the South also uses about three times as much pesticide and 17% more total

energy per crop acre as the non-South (USDA 1977, p. 22). It is a high cost agriculture and one of considerable risk. As a consequence, land used for crops in the South has been more variable than in the rest of the United States or, for example, the Corn Belt. Cropland moving out of production in the mid-sixties suggests that the southern region has relatively more marginal soils than in the rest of the country.

Labor use data in agriculture suggests a large release of surplus labor to nonfarm employment during the 1950s and 1960s. Labor use in the South remains higher per crop acre than in the rest of the country: in 1945 versus 1979, the hours per acre were 68 and 13 in the three-region South and 16 and 5 in the non-South. The difference is in part due to the fact that some crops grown in the South—especially tobacco—remain labor intensive and in part to smaller average size farms which utilize smaller-scaled equipment.

Output

Farm output in the Delta region, as defined by USDA, has shown more growth than on U.S. farms. Growth in farm output in the Southeast region has been similar to that for the nation and the Corn Belt; the Appalachian region has lagged other regions. Since 1945, acres of corn, cotton, peanuts, tobacco, and hay have decreased. The acres planted to corn and harvested for hay declined as animal power declined. Corn acreage in the Old South decreased from 25.3 million in 1934–43 to little more than 7 million in 1978. Cotton acreage declined largely because of a comparative advantage in the Southwest. The newly developed mechanized power and equipment and chemical weed control was much better adapted to the large irrigated farms in California and Arizona, the large farms in Texas and Oklahoma, and the Delta areas than to the rainfed, smaller, and, frequently, hilly farms in the Southeast. In the Old South, cotton has been reduced essentially to the Delta areas. Georgia, the "heart" of the Old South with 4.8 million acres of cotton in 1911–15, had only 111 thousand acres in 1978. Peanut and tobacco acreage declined in large part because of supply control programs increased and the acreage of timber on southern farms has declined. In terms of production, peanuts, soybeans, and wheat have increased while corn, cotton, and tobacco have declined (USDA 1980).

Indexes of farm output indicate that livestock output has grown more rapidly in the South than crop output. This result is in contrast to what has happened in the United States in general and in the Corn Belt. Cattle, poultry, and egg production have been the big gainers. Hog numbers are down over early post-World War II years and milk production has declined 40% over the past thirty years.

Productivity

The Old South has an image of a poor agricultural region of small farms. This image derives in large part from the sharecropper era and the plight of the "Cotton South" during the boll weevil infestation. The index of farm productivity indicates that the agriculture of the Mississippi Delta has outperformed U.S. agriculture and that of the Corn Belt in terms of relative change. The Southeast and Appalachian regions have performed about the same as the Corn Belt and the country in general (USDA 1981b).

Yield increases of crops of primary importance to the South and the fertilizer use data suggest a progressive innovative agriculture; for example, peanut yields in Georgia have increased by a factor of 4.8 since 1945. Cotton yield in Mississippi have increased by a factor of 1.9, and tobacco yields in North Carolina have increased by 1.8. Although not directly comparable, soybean and corn yields in Illinois have increased by factors of about 1.8 and 2.8, respectively, during the same period, and cotton yields in California have increased by a factor of 1.5.

The Old South has made considerable progress but it still contains many poor farmers. There are in all regions great interfarm variations and this is perhaps more true in the South than in other regions. Small farms in terms of acreage mean a relatively low equity base. On 1 January 1979, the equity per farm in the South was only 25% that of the average farm in the remainder of the U.S.—$85,300 compared with $354,000. This low resource

Low net returns mean less funds for investment purposes, and the cycle of relatively small units is perpetuated.

Institutional Factors

In terms of human capital investments, the South remains behind. In 1976, about 57% of the population above eighteen years of age graduated from high school in the South compared to 67% in the United States. Expenditures in public schools per pupil are relatively low and only Virginia ranks in the upper half of the states on the basis of expenditure per pupil in average daily attendance (U.S. Dept. of Commerce 1980).

Earlier we suggested that the agriculture of the South was a relatively high risk enterprise, and we agreed with Schuh that risks in U.S. agriculture are increasing. Historically, the South has effectively used agricultural programs to maintain or increase income and to reduce risks. A greater proportion of cash receipts plus value of home consumption in the South came from government payments during the fifties and sixties than for agriculture outside the South. In 1945 and since 1975, this proportion in the South was lower than in the non-South.

We hasten to point out that government payments are an imperfect measure of net effectiveness in the use of policy. The South also has been placed at a disadvantage by policy. Perhaps the best example was when the Southwest was able to obtain public investments in water project development which enabled that region to obtain a comparative advantage in cotton production. The distributional aspects of this policy are particularly disturbing because the advantage went to large farms at the expense of small farms.

The body politic of the South has recognized a payoff to policy and developed power by exploiting the tenure system in Congress. Tobacco politics stand out. The result is a contradiction in policy, with the USDA encouraging production at a time when tobacco use is being discouraged by the Department of Health and Human Services.

There is evidence that the agricultural sector in the South is exercising power in state legislatures to obtain funds for research and extension activities. For example, in 1979, the state appropriations in Arkansas, Louisiana, and Mississippi for extension work and for state agricultural experiment stations reported research exceeded appropriations in the midwestern states of Illinois, Iowa, and Missouri. Collectively, the three southern states outappropriated the three midwestern states by 30%. On a per farm or per capita basis, the South out-appropriated the midwestern states by a factor of 3.

Concluding Remarks

Agriculture today is characterized by a set of increasing international linkages. These strengthened linkages are most apparent in the commodity markets. Indeed, one only has to look at U.S. agricultural exports, which have grown to the $40 billion range, to be amazed at this rapid development during the last decade. Schuh has argued effectively that changes in the national and international financial markets are also increasing the number and strength of ties between the agriculture and nonagricultural sectors in an international arena.

Schuh also has argued that growing interdependencies between agriculture and nonagricultural sectors have increased risks in agriculture and that national and international economic policies will do more to condition what happens to agriculture in the future than will traditional commodity programs.

While the international arena is now looking more like the pre-1930s era, the position of the Old South has changed. In 1935–40, cotton and tobacco accounted for 66% of the total value of farm exports. These two crops accounted for little more than 10% of the total in 1978, and a much smaller share of the cotton was produced in the Old South.

Every agricultural region has its problems, but in addition to problems that face agriculture in general, the South perhaps experiences more biological risks than many other parts of the nation because of its warm, moist climate which is attractive to pests, and, except in the Delta, because of its older, more leached soils.

There probably will be some further migration of farm labor to nonfarm employment. But as many persons seek less congestion, and in many instances a warmer climate in which to live, labor markets are created which provide nonfarm employment for resident farm labor. We expect this market for surplus farm labor to become an increasingly important mechanism for adjustment and labor migration that requires moving to an urban setting, less

important. This adjustment mechanism will increase further southern agriculture's interdependence with the nonfarm sector.

Population migration to the Sun Belt has placed greater demands on the indigenous resource base in parts of the South. In these places, water, noise, space, and nonpoint pollution problems will occur increasingly at the interface of the farm and nonfarm sectors. These trends, too, will add to risks in southern agriculture as migration to the Sun Belt continues.

Agriculture of the South effectively used commodity policies from the 1930s to reduce price and income fluctuations. What happens to its agriculture in the 1980s will, by and large, depend on the technological and institutional mechanisms which are created to accommodate adjustment to its more risky environment. It may be that expected net income to farmers will increase sufficiently to make elements contributing to risk seem less important. This may be the case if the international demand for food shifts faster than new technology and resources can shift supply. In recent years, such a scenario seems more realistic than it did in the mid-1960s. If relative food prices increase, U.S. consumer interests may take a more explicit role in agricultural policy issues. U.S. consumers may find it to their advantage to encourage policies that increase agricultural output internationally as well as at home.

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Changes in the Black Community

Paul L. Wall

The Division of Behavioral Science Research at Tuskegee Institute is concluding a followup investigation of Charles S. Johnson's classic study of southern rural blacks, entitled "Shadow of the Plantation." The study was published in 1934. The area selected for study was Macon County, Alabama—one of the "black belt" counties which historically formed the region of cotton culture in the South. It is also the county in which Tuskegee Institute is located. The results of this study provide the base line data for our current restudy of the same area almost fifty years later.

At the time of the original study, the plantation system, under which blacks had lived for generations, was seen as a sick and dying institution, unable to compete successfully with other cotton-raising areas in the world market. The blacks who were the subjects of the study were seen as folk people. Given these conceptualizations, Robert E. Park, in his introduction to *Shadow of the Plantation,* proposes a conceptual framework which guided the study:

> It has been observed that as long as their social institutions are functioning normally, primitive people ordinarily exhibit an extraordinary zest in the life they lead, even when that life, like that of the Eskimo in the frozen North or the pigmies in the steaming forest of Central Africa, seems to be one of constant privation and hardship.
>
> On the other hand, when some catastrophe occurs which undermines the traditional structure of their society, they sometimes lose their natural lust for life, and that euphoria which enabled them to support the hardships of the primitive existence frequently deserts them. (p. xiii)

The demise of the plantation system was seen as one such catastrophe. A recurring theme in this original work is the loneliness, the apathy, and the monotony of life observed among the black tenants who lived in relative isolation on the plantation and farms and who were so completely dependent upon their landlords.

The study is based on 612 families located in eight settlements in Macon County. These families represented about 10% of the black population in the county in 1930. The eight settlements were neither political nor administrative divisions. In their isolation, they represented communities to which the people felt they belonged and where "they lived almost within sight of the passing world, dully alive, in an intricate alliance with a tradition which has survived the plantation itself" (p. 12). Johnson's essential observation in his study is:

> . . . that the Negro population of this section of Macon County has its own social heritage which, in a relatively complete isolation, has had little chance for modification from without or within. Patterns of life, social codes, as well as social attitudes, were set in the economy of slavery.
>
> . . . The strength and apparent permanence of this early cultural set have made it virtually impossible for newer generations to escape the influence of the patterns of work and general social behavior transmitted by their elders.
>
> . . . It is unquestionably the *economic system* in which they live, quite as much or even more than the landlords, that is responsible for their plight (p. 16).

With respect to the people, Johnson observes not one but nine types of family structure: stable old families; families with strong maternal dominance; female heads; male heads of transient families; stable nonlegal unions; nonagricultural families; stable legal unions; disorganized legal unions; stable familes with advanced standards. This range of social groupings was viewed as atypical if the family as a universal pattern is defined as consisting of father, mother, and their children. Furthermore, the family was seen as matriarchal in character (p. 29).

With respect to the economic life of the community, it was essentially agricultural, with the occupation of almost every member of the community old enough to work being that of farming. While there were indeed black farm owners and black farm managers, the

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vast majority of blacks worked as tenant farmers and farm laborers.

With respect to shelter, the dwellings that were available to tenant farmers presented a dreary monotony of weatherworn cabins. The physical form varied little; there were few alternative models available to stimulate interest in anything else.

With respect to education, Johnson observes that literacy is not not an asset in the plantation economy. Reading and figuring carry elements of danger to established relationships. The tradition that an education was unnecessary persisted strongly. However, the younger generation at the time of the study saw education for their children as an escape from their own dismal economic plight. But the costs associated with education of the children made the odds formidable ones.

About 25% of the male heads of households were illiterate and about 20% of the 579 women heads—either joint or sole—were illiterate. Almost 50% of the male heads were "bare literates," i.e., they had had from one to five years of schooling. When education is related to income, it is obvious that the more economically successful families were those who were neither illiterate nor possessed more education than the system required or was allowed.

These brief references to some of the salient observations made by Johnson and his colleagues in 1930 reflect the then current external pressures on the plantation system itself. Johnson concludes that "the fate of the tenant is but an aspect of the fate of the southern farmer generally, and the plight of all of those await a comprehensive planning, which affects not merely the South but the nation" (p. 212).

Any investigation seeking to trace out social change requires as a starting point not only base line data but the identification of sources of change as well. Johnson observes in 1930 that changes were occurring slowly and that they could be observed and measured. He includes as sources of cultural penetration into the community, the school, the church, the influence of people educated outside the community, return migrants and exposures to extension and demonstration programs in health and agriculture (p. 209). The latter largely eminated from Tuskegee Institute.

In our current restudy, two types of changes occurring in the area since 1930 have been identified: political/legal changes and technological/material changes.

Among the political/legal changes are the penetrations into the area of larger forces associated with such efforts as the New Deal programs, resettlement efforts as, for example, those associated with launching TVA and the establishment of model farming communities of the "40 acres and a mule" type. In Macon County, some of these efforts were successful while others failed. World War II not only provided cultural exposures for the eligible males far beyond the isolated limits of these rural settlements but also benefits for those returning as veterans in relation to housing and education. More important, this exposure provided them a heightened awareness of prevailing social injustices and the stimulus to redress them.

The case of *Brown* vs. *Topeka, Kansas* in 1954 eventually resulted in the closing of the one- and two-room rural schools, the emergence of a consolidated county school system as well as a system of private, white academies which thwarted efforts aimed at achieving racial integration of public schools.

In 1957, Alabama Legislature Senate Bill #291 became law. It was designed to limit political participation of blacks by eliminating from the City of Tuskegee through gerrymandering, approximately 3,500 black citizens. It would eliminate 400 of the city's 409 registered black voters. This effort to disenfranchise rural black citizens was ruled unconstitutional four years later in February 1961, in *Gomillion* vs. *Lightfoote*.

Three years later, in 1964, the impact of Mrs. Rosa Parks' refusal to relinquish her seat on a public bus to a white passenger sparked the mounting discontent of blacks of their position in a segregated society—not only in Alabama but across the nation.

The 1960s were the years of the Great Society, which ushered in the creation of social programs within Macon County that were to change many patterns of living among the rural black citizenry.

Other observable changes of the technological/material type included an enormously improved county road system, the exposure to mass culture through the medium of television, the availability of rural electricity, propane gas, indoor plumbing, public health facilities, improved housing, and the automobile.

Concurrently, the loss of farm land ownership among blacks continued to increase while the economic base of the state, in gen-

eral, and Macon County, in particular, shifted from reliance on a single staple crop—cotton—to reliance on more diversified agricultural efforts including soybean production and cattle raising.

The decade of the 1970s has been heralded as a decade of change for rural America. Employment opportunities expanded and broadened, a reversal occurred in the long-time trend of rural outmigration, and technological advances in transportation and communication transformed rural life. During this decade, considerable progress was made in the quantity and quality of public facilities and services available to rural people. Despite this progress, rural America continues to lag behind urban America in social and economic well-being as observed in such diverse problem areas as education, health, nutrition, unemployment, civil rights, land retention, and the list continues.

It is true that the annual growth rate of rural areas has averaged about 1.3%—exceeding the rate of growth in urban areas by more than 40%. Rural employment is growing and diversifying with new jobs being created at a faster rate than in urban areas. Rural America is growing, but too many rural residents have failed to benefit from that growth. A disproportionate share of the nation's poor still lives in rural areas and virtually all of the nation's persistently poor counties are rural. Additionally, a disproportionately large number of lower income rural residents are blacks, Hispanics, or Native Americans.

In general, the achievements of blacks during the 1970s have been difficult to assess. It has been observed that sharp differences exist between white and black views regarding the quality of life of blacks in America.

In a 1980 Gallup Poll, 75% of whites thought that during the past decade the quality of life for blacks had gotten better, while 45% of blacks thought it had remained about the same or gotten worse. Proponents of the "dramatic improvements thesis" rely on income and occupational data to support the notion that more blacks are now comfortable members of the middle class. Yet, Vernon Jordan of the National Urban League provides a competing assessment:

> For black Americans the decade of the 1970's was a time in which many of their hopes, raised by the civil rights victories of the 1960's, withered away; a time in which they saw the loss of much of the momentum that seemed to be propelling the nation along the road to true equality for all its citizens.

In our society, advancement is ultimately measured in terms of earned income and, by extension, jobs.

And this brings me to one of the most significant patterns that is emerging in the analysis of the data in our restudy of rural blacks in Macon County, Alabama.

Our sample consists of 199 families and includes socioeconomic data on about 3,000 individuals. Over half of these families lived in still-existing communities that were included in the original study.

With respect to employment, 50% were unemployed, about 27% were retired or disabled, about 17% were employed full-time, and about 3% were employed part time.

While there was greater diversity in the range of occupations, 21% of the men were farm laborers and 25% of the women were farm housewives. The remaining occupations could be classified as service workers, textile workers and nonfarm laborers.

With respect to income, over 70% earned less than $3,000 annually.

In 1959, the total median family income for the State of Alabama was $3,927; in 1969, it was $7,26[illegible]; and in 1975, it was $11,785. However, when these figures are broken down by race, the black to white median income ratio revealed that in 1959, blacks earned 42% of what whites earned; in 1969, 49% and in 1975, 58% of what whites earned.

This inequality seems to be a persistent pattern in the state, and there is no indication that the ratio will differ significantly when the 1980 Census is published.

Fifty years after Johnson's observations, the plight of these rural black families in Macon County, Alabama is still awaiting the comprehensive planning which he concludes is needed—not merely for them, but for the rural South and the nation as a whole. Any effort at comprehensive planning must address the inequality inherent in these persistent, systemic economic forces.

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Deregulation and Its Consequences for Agriculture
(Orlo Sorenson, Kansas State University, Presiding)

Impacts of Regulatory Change on Financial Markets for Agriculture

Peter J. Barry

The beginning of the 1980s is a landmark in U.S. financial markets because of changes in the regulatory environment that mark this time. Especially important was passage of the "Depository Institutions Deregulation and Monetary Control Act of 1980" (DIDMC). Also under consideration is liberalization of geographic restrictions on banking and further modifications of regulations for financial institutions. Other issues specific to financial markets for agriculture include passage of the Farm Credit Act Amendments of 1980, a more conservative role for government credit programs, and outside equity financing in the farm sector.

My purposes here are to evaluate the possible consequences of regulatory change for agricultural finance and to consider implications for research and policy. The regulatory environment of the financial services industry is reviewed with emphasis on debt capital for agriculture. Specific regulatory issues then are analyzed, including the distribution of financial services among farm lenders and between private and public channels.

Financial Services and Regulations

The major services provided by financial markets include (*a*) an efficient payments mechanism for transactions, (*b*) a means of allocating and bearing risks, and (*c*) an intermediation system for channeling savings into investment. The intangible nature of these services and related financial assets requires confidence, trust, and stability among the markets' participants in order for financial markets to function effectively. Accordingly, these markets experience considerable regulation for purposes of safeguarding savers and investors, standardizing instruments and practices, modifying competition, responding to imperfections and gaps in financial services, and providing for effective monetary policy. Regulations take many forms: restraints on geographic expansion, as in branching and holding company regulations; mandatory specialization in some services (housing or farm lending, transactions accounts); portfolio diversification through reserve and capital requirements, loan limits and asset allocations; interest rate controls on deposits and loans; special borrowing privileges; fair trade practices; and public programs for credit and insurance.

Regulations yield many positive effects, as intended. However, they also may impose substantial costs on participants in financial markets as changes occur in economic, social, and institutional conditions. Inequities can arise that discourage savings, impede flows of funds, and destabilize fund availability from some intermediaries. Achieving equitable regulations among different intermediaries is difficult. High costs of compliance cause lower efficiency of intermediation. Regulations also have induced financial innovations to circumvent government policies, thus further distorting and destabilizing financial markets.

When these costs of regulations become excessive, as is the case in recent years, the stage is set for substantial regulatory change. Numerous conditions have prompted the current changes. Included are disintermediation problems associated with high inflation and interest rates, increasing competition among financial institutions, new entrants to the financial services industry, new electronic technologies in funds flows, changing methods of implementing monetary policies and attrition of banks from the Federal Reserve System, and disadvantages of small savers.

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In financial markets for agriculture, the stresses brought by these conditions, along with strong growth in farm debt, have fallen mostly on smaller banks that are heavily involved in farm lending and on their farm and farm-related borrowers (Barry; Hughes et al.). About half of total farm loans at commercial banks are held by 6,000 or so banks with total assets less than $100 million, in which farm loans comprise more than 25% of total loans. Moreover, the nearly 13,000 of these small banks hold more than 70% of total farm loans at banks. These banks rely heavily on local markets for sources of loan funds and have experienced losses of deposits in times of rising interest rates. Their growth in loan demand has frequently exceeded growth in lending capacity, and they are especially vulnerable to changes in local farm income conditions. These conditions have caused periodic stresses in bank liquidity, large swings in fund availability, and increased financial risks for farmers. One indicator of these stresses is the sharp decline in banks' share of total non-real estate farm debt from a high of 52.2% in 1974 to about 38.3% in 1981.

In contrast, other major farm lenders, like the Cooperative Farm Credit System (FCS), the U.S. government, life insurance companies, and many merchants and dealers, are large in size, regional or national in scope, and organized to obtain nonlocal sources of funds for rural markets. Among these, FCS has become the dominant lender in farm credit markets, holding more than 30% of total farm debt, with federal land banks showing strong growth in real estate debt. Shares of total non-real estate farm debt held by government through the Farmers Home Administration (FmHA), Commodity Credit Corporation (CCC), and Small Business Administration have also grown rapidly, totaling about 22% in 1981, up from about 5% in 1974.

The strong growth in farm loan demand, along with substantial variability in farm incomes, have severely tested rural financial markets as channels through which agricultural banks generate funds. These conditions heighten the need for access to nonlocal sources of funds, especially during times adverse to farm income. However, agricultural banks have had much difficulty in developing this access. Instead, nonlocal funds, from government loan programs especially, have flowed abundantly to agriculture in recent years, thus shifting the balance to heavy reliance on public channels. In this light, the regulatory changes that are occurring will have profound implications for relationships among farm lenders and for the provision of financial services to agriculture.

The 1980 DIDMC Act

The 1980 DIDMC culminated a decade-long process of regulatory review by various commissions, congressional debate, and the financial services industry (Federal Reserve Bank). Major elements of the act include the imposition of uniform Federal Reserve requirements on similar classes of reservable liabilities at all depository institutions, provision for the orderly phase-out by 1986 of interest rate ceilings on deposits, nationwide authorization of interest-bearing transaction accounts, temporary preemption of state usury laws on certain types of loans, immediate increases in federal insurance coverage on deposits and accounts, more liberal investments and lending limits of thrifts, and requiring the Federal Reserve to price competitively its individual services and grant all depository institutions access to these services.

Preliminary appraisals indicate that the 1980 act should have the greatest impact on smaller banks which have greater problems in fund availability and less flexibility in balance sheet management (Miller). Smaller agricultural banks, especially, should gain loanable funds from reduced reserve requirements and should eventually be able to compete more equitably for savings funds in local markets, especially when interest rates are high. Pressure to innovate in acquiring local funds will be lessened during these periods with more market-oriented pricing on loans, services, and sources of funds.

If, however, more equitable access to local deposits comes at much higher interest costs, then smaller banks will be hard pressed to compete in farm lending, even if profit margins are lower because of greater competition. How much the cost of funds will increase as the DIDMC phases in is difficult to foresee. Federal Reserve data show that a relatively high portion of agricultural banks' costs of funds already reflects market factors from growing use of money market certificates and 30-month certificates of deposit, both having ceiling rates indexed to yields on U.S. government securities. Recent studies also indicate that community banks have held their

profit margins through the stresses of 1979–80 and are adjusting successfully to interest-bearing transaction accounts as did New England banks earlier. But, the case could differ for agricultural banks that compete with other farm lenders like FCS and the federal government.

Structural Change in Banking

Conditions now are favorable for significant structural changes in the geographic structure of banking. Federal laws about banking structure reflect an historic concern about undue concentration of economic power, competitive equality between state and national banks, and state sovereignty in setting restrictions. These concerns are expressed in the McFadden Act, which prohibits interstate branching and reserves intrastate branching policies to each state; and in the Douglas Amendment to the Bank Holding Company Act of 1956, which prevents bank holding companies from buying or establishing out-of-state subsidiaries unless authorized by the states. The result is a diverse set of state limitations on branching and holding companies.

A presidential task force has comprehensively studied the effects of these regulations, and in a 1981 report to Congress concluded that the McFadden Act and the Douglas Amendment are "increasingly ineffective, inequitable, inefficient, and anachronistic, and that the existing de facto system of interstate banking should be ratified and further liberalized through a phased relaxation of current geographic restraints" (U.S. Treasury Dep., p. 17). The Report recommends a phased liberalization to avoid serious instabilities, initially modifying the Douglas Amendment and later the McFadden Act.

The report is based on research findings that liberalization (*a*) could improve competition in local markets without significant increase in undue concentration of economic power; (*b*) would increase the range of financial services in local communities; (*c*) would improve banking performance through greater actual and potential competition; (*d*) does not significantly threaten the viability of small banks, the safety and stability of the banking system, or dual chartering; and (*e*) would create more equitable competition between bank and nonbanking institutions. Anticompetitive behavior resulting from geographic liberalization should be offset by greater reliance on antitrust laws, increased potential competition from other banks, and growing nonbank competition.

The report's research findings indicate that smaller, independent banks historically have withstood competition from new bank competitors, albeit with the pro-competitive effects of lower prices for services and lower earnings. Evidence is cited that unit banks in statewide branching states use more of their resources for loans than do similar banks in unit banking states and that average returns on total assets decline with increasing bank size, are highest in unit banking states and lowest in statewide branching, and are higher for banks in non-SMSAs. Factors explaining the survival and prospering of small and medium size banks faced with large, branch bank competition include their location in rural or nonmetropolitan markets where earnings are higher and competition apparently less, their competitive pricing of necessary services often through correspondent arrangements, loyalty of customers, and innovations in operations and policies. These factors are consistent with earlier views that rural unit banks have made important use of mechanisms designed to cope with problems in financing farmers (Brake and Melichar).

Farm Credit Act Amendments of 1980

Passage of the Farm Credit Amendments culminated a long legislative process that yielded new insight on the competitive pressures in farm credit markets. Major provisions in the act, designed to update and improve the operation of FCS, include (Wilkinson): (*a*) authorization for Banks for Cooperatives (BCs) to finance agricultural export activities benefiting U.S. cooperatives; (*b*) reduced requirements in farmer-member eligibility in certain cooperatives financed by BCs; (*c*) provision of Federal Land Banks (FLB) and Production Credit Associations (PCA) to finance more fully the processing and marketing activities of eligible borrowers; (*d*) expanded limits for FLBs on loans guaranteed by a federal or state agency; and (*e*) increased cooperation between FCS, commercial banks, and other lenders.

Most of these changes should have relatively minor effects on financing in the farm sector; however, impacts on nonfarm financing may be greater depending on FCS re-

sponses to the first three provisions. The increased cooperation with commercial banks involves further development of loan participations between banks and PCAs, and new authorization for participations between FLBs and banks. Significant revisions also occurred in the authority for Federal Intermediate Credit Banks (FICBs) to loan to or discount loans from other financing institutions (OFI), including commercial banks, through direct arrangements or agricultural credit corporations. The statute now clearly indicates that FICB services are to be reasonably available to OFIs that (*a*) are significantly involved in agricultural or aquatic lending, (*b*) have limited access to regional or national capital markets, (*c*) have continuing need for supplementary funds for agricultural and aquatic lending, and (*d*) do not use FICB services to expand other types of lending. These revisions are intended to put OFIs in essentially the same position as PCAs in their ability to use FICB services.

How commercial banks will respond to these revisions is uncertain, although FCS anticipates an expanded use of loan participations and OFI discounting as regulations for these programs are formulated. The development of FICBs in 1923 was to provide rural banks with new funds by discounting their agricultural loans. Because FICBs were little used by banks, Congress authorized the establishment in 1933 of PCAs who were also to obtain loan funds from FICBs and who would later gain ownership and control. 1971 legislation also allowed PCAs to participate with banks on agricultural loans. The volume of OFI discounting and bank participations has remained low, amounting in 1980 to about 4.5% of FCS outstanding non-real estate debt. Thus, the renewed interest by commercial banks in using FCS as a source of loan funds, expressed in part by debate on the 1980 act, is set against a long history of relatively low use by banks and differences among the FICBs in their willingness to consider OFI relationships.

In a broader context, the debate on the 1980 act brought to light substantial differences in the regulatory environment for commercial banks and the FCS that influence their competitive balance in farm credit markets (Webb, Barry). Included among these differences were the effects of income tax obligations, ranges of financial services and borrowing clientele, legal reserve requirements and lending limits, geographic restrictions, stringency of regulation and supervision, and access to national financial markets. It is especially difficult, however, to evaluate competitive equality among depository and nondepository institutions using similar evaluative criteria when these institutions also serve different clientele and provide different services.

Government Credit Programs

The recent growth in government's farm lending has softened the impacts of volatile credit markets and variable farm incomes on the farm sector. However, much concern has surfaced about special credit treatment in agriculture, the proper balance between public and private sectors, the degree of subsidy involved, and the resulting tax burdens. Also important are the kinds of farmers involved and the relationships with commercial lenders. A recent study indicates that larger proportions of funds in FmHA's Economic Emergency Program went to farmers with relatively large net worths and strong income potential than occurred in the traditional FmHA loan programs (Hughes et al.). Thus the actual or potential availability of loan funds on concessionary terms from the government encourages farmers to use or to become eligible for these programs, attracts customers away from commercial lenders, and discourages participation of some lenders. Some observers (Lee, Gabriel, Boehlje; Benjamin) suggest the past structure of farm credit markets, including the prominence of government programs, has resulted in overfinancing of the farm sector, thus constraining resource adjustment, shifting risk bearing to the government, and capitalizing the effects of concessionary financing terms into higher values of land and other farm assets.

The new administration has sought to reduce the magnitude and subsidy in FmHA programs and largely return its role to a lender of last resort. Besides the high taxpayer cost of government programs, these changes are also based on stronger financial performances anticipated for the farm sector and more moderate growth in farm debt than occurred in the late 1970s (Hughes, Barry); expanded use of new Federal Crop Insurance Programs for disaster protection; more effective use of loan guarantees in private credit programs, tailored to beginning farmers or other target groups;

and greater innovation by commercial lenders in acquiring loan funds and in countering business and financial risks in agriculture. In contrast, credit supplied by CCC likely will not change much. Their programs represent a sophisticated financial control system that combines buffering of price fluctuations for many commodities with valuable liquidity and flexibility for farmers in marketing their crops.

Implications for Financial Markets and Farmers

Less extensive involvement by Government in the 1980s should enhance farm lending by private sector lenders, especially if long term farm income conditions remain favorable. Moreover, the 1980 DIDMC should enable smaller, agricultural banks to compete more equitably for savings that have been channeled away from local markets. However, competition among depository institutions will increase from the expanded authorities of the thrift institutions. Costs of funds and interest rates on farm loans should remain high and volatile, reflecting closer integration of local and nonlocal markets, greater use of price versus non-price responses by lenders, and continued implementation of monetary policies in terms of monetary aggregates. Agricultural banks that experience high, more volatile costs of funds along with vulnerability to local farm conditions will have strong competition from FCS lenders. Intense price competition will occur in some cases, nonprice competition in others, and participation or discounting arrangements in still others. If competition and high costs of funds severely depress bank operating margins, the press for bank mergers and large size will increase. In any case, smaller banks will continue to need reliable, cost effective access to nonlocal sources of funds. Liberalization of geographic restrictions on banking may offer greater flexibility for tapping nonlocal funds, and also yield pro-competitive effects on bank performance.

Evaluating the impacts of these regulatory changes on performance of financial markets and intermediaries is a rich setting for new research. Especially important are innovations in pricing and funds acquisition, evaluating the impacts of geographic liberalization on farmers and other borrower groups, and exploring the differences between banks and nonbank lenders of the loan-deposit feedback phenomenon and its impacts on pricing policies, terms of competition, and market shares as regulations change. Moreover, interest rates should become a stronger determinant of farmers' loan demand and choice of lender. Banks and PCAs, for example, traditionally were considered to be in segmented markets (Thompson). The narrow spreads between their farm loan rates until the late 1970s meant farmers' loan decisions were largely based on nonprice factors, with banks benefitting from strong reliance on interest-free demand deposits. As table 1 shows, these spreads on gross loan rates have changed sharply (Webb). The wider spread in favor of FCS is attributed to banks' growing reliance on higher-cost time deposits with variable ceiling rates. Moreover, the FCS practice of pricing loans with variable rates that are adjusted periodically for changes in average costs of funds, the average maturity of which likely exceeds banks', moderates the pace and magnitude of their rate changes.

Differences between lenders in rate composition are also important. Table 2 indicates average costs of money, lending costs, losses or loss provisions, taxes, and earnings per loan dollar for banks and FCS lenders in 1979. Bank data are from the functional cost analysis reports on commercial and agricultural loans of 349 banks with total deposits less than $50 million. FCS data are from annual reports for 425 PCAs and 12 FLBs. The data are not strictly comparable because of differences in accounting methods, types of loans, loss treatment, tax omissions for banks, omission of stock and deposit balances, and other features of the deposit relationship. Still, they show important differences for these lenders. Costs of money were a lower proportion of total lending costs in 1979 for banks than for PCAs. Operating costs per loan dollar were higher on average for banks, although substantial differences occur among some PCAs.

The largest difference in rate composition between bank and FCS lenders is in earnings rates. The before-tax return on loan assets for the reporting banks averaged 3.02% in 1979, equivalent to a 34.6% before-tax return on equity for these banks' ratio of equity to total assets. In 1979 banks could sustain these favorable earning rates while remaining competitive with PCA rates on farm loans because of differences in their costs of money. Sharp increases in banks' money costs along with their need or desire to keep earnings rates at

Table 1. Interest Rates on Farm Loans from Banks and Farm Credit System Lenders

	Non-Real Estate Loans		Real Estate		Spreads		
	Large Banks	Other Banks	PCAs	FLB	Banks (Other)-PCA	Banks (Large)-PCA	Banks (Other)-FLB
1950–59 (average)	6.5		6.4	4.1	0.1	0.1	2.4
1960–69 (average)	7.0		6.9	5.2	0.1	0.1	1.8
1970–76 (average)	8.4		8.3	6.9	0.1	0.1	1.5
1977 I	8.3	8.9	8.2	8.5	0.7	0.1	0.4
II	8.1	8.9	8.1	8.4	0.8	0.0	0.5
III	8.4	8.9	7.9	8.3	1.0	0.5	0.6
IV	9.1	9.0	8.0	8.3	1.0	1.1	0.7
1978 I	9.3	9.1	8.4	8.2	0.7	0.9	0.9
II	9.6	9.2	8.7	8.3	0.5	0.9	0.9
III	10.4	9.3	9.0	8.3	0.3	1.4	1.0
IV	11.7	10.0	9.2	8.4	0.8	2.5	1.6
1979 I	12.5	10.4	10.0	8.7	0.4	2.5	1.7
II	12.8	10.7	10.6	9.0	0.1	2.2	1.7
III	12.9	10.9	10.9	9.3	0.0	2.0	1.6
IV	16.2	13.1	11.0	9.3	2.1	5.2	3.8
1980 I	16.0	13.7	12.1	9.8	1.6	3.9	3.9
II	18.5	17.1	13.8	10.6	3.3	4.7	6.5
III	12.8	13.7	13.4	10.6	0.3	−0.6	3.1
IV	16.3	15.3	12.2	10.3	3.1	4.1	5.0
1981 I	19.9	17.5	13.1	10.6	4.4	6.8	6.9

Source Melichar and Waldheger.

earlier levels appear to explain the widening spread in farm loan rates. Hence, banks' ability to sustain their positions in farm lending under current conditions rests on several factors: reductions in earnings, provision of other financial services, nonprice factors including gains from the loan-deposit feedback, price discrimination between farm and nonfarm loans, and farmers' responses to different levels and volatilities of rates.

The current financial environment also brings new considerations about the funds-generating capacity of rural markets, with emphasis on banks' access to nonlocal funds. The needs for this access—overline loans, seasonal factors, liquidity pressures—continue despite the recent regulatory changes. A recent symposium gave an in-depth look at "Future Sources of Loanable Funds for Agricultural Banks" through correspondent banking, the federal government, the Federal Reserve System, the Farm Credit System, banking in-

Table 2. Interest Rate Composition on Farm Loans

	Commercial Bank $0 to $50 mill. Deposits	Production Credit Assoc.	Federal Land Banks
Cost components			
Cost of money (interest, noninterest)	5.90	9.04	7.46
Operating expenses[a]	1.61	1.21	.51
Losses or loss provision[b] and taxes	.32	.62	.20
Net earnings	3.02	.96	.84
Gross yield	10.85	11.83	9.01
Yield components			
Interest	10.70	10.71	8.65
Other income or adjustments	.15	.38	.36
Patronage refund, FICB		.74	

[a] Operating expenses for individual PCAs ranged from .36 to 3.62.

[b] Net losses for reporting banks; loss provision and federal and other income taxes for PCA and FLB.

novations in balance sheet management, and forming a new intermediation system for groups of banks. Preferences appear strong for developing funds access through commercial channels either by more reliable correspondent arrangements, joint ventures, or other types of direct access to national and secondary markets. However, a strong paradox is emerging in that the most stable, efficient, cost-effective, and farm-related source of funds for agricultural banks likely is the Farm Credit System, which also is regarded as the main competition in farm lending for these banks.

The future may bring increasing need for policy makers to come to grips with relationships between FCS and banks in intermediating funds to agriculture. Regulatory differences cited earlier warrant further study. Moreover, stronger demand by banks for OFI discounting and loan participations would increase and destabilize FCS' own needs for funds, thus jeopardizing their relatively unconstrained access to the national financial markets, especially in current times of short maturities on financial assets. However, designing a new national intermediation system for agricultural banking seems to duplicate needlessly FCS facilities unless it accommodates a broader range of loans.

The recent banking legislation also had no impact on banks' legal lending limits, which often constrain the capacity to finance fully their most valued farm customers. New policies could be considered to preempt limits on farm loans that are protected by commercial or public insurance. Smaller banks could then avoid being compelled by regulation to involve other lenders or decline large loan requests.

Further innovation within banking of new financial instruments, institutions, secondary markets, and loan practices should help resolve the funding problems. Research can play an important role in monitoring new developments, evaluating their feasibility, considering regulatory schemes, and analyzing market performance. Modeling procedures and empirical measurement techniques also are suited to evaluating flows of funds in local markets, loan-deposit relationships, local business activity, and individual intermediaries (Boehlje, Harris, Hoskins). Outside equity financing in agriculture also warrants further attention. Some parts of agriculture have long attracted outside equity through direct investment, limited partnerships, common stock and agency services, with their appeal resting on profit potential and tax sheltering of high incomes. Newer channels are associated with foreign investment, pension funds, life insurance companies, and equity participation loans considered by some lenders. The low incidence of regulation for these channels could change in the future with important implications for the structure of agriculture and its financing.

Evaluating the impacts of financial regulations on the farm sector also provides a rich agenda for future research. Farmers should find farm credit markets more in the hands of private and cooperative lenders who will compete more vigorously for their market shares. High levels and volatility of interest rates will continue to bring high financial risks in the farm sector, although rate variability should partially displace the past variability of fund availability from agricultural banks. Differential loan pricing among farm customers should increase to reflect more fully their credit and liquidity risks and lending costs. Skills in liquidity and risk management must improve in response to added risks in financial markets and curtailment of credit reserves from government programs.

Impacts on the distribution of debt capacity among different sizes and types of farms will depend strongly on their relative skills in risk management. Larger operations likely will continue to show favorable performance, although management and entrepreneurship will be more crucial than government programs. Further growth in size, specialization, and capital intensity of farming operations should impact on the structure of financial institutions by further concentrating farm loan portfolios and favoring the risk bearing advantages of larger, geographically dispersed lending institutions. For banks, the pattern of agricultural financing may follow closely the evolving structure of agriculture with larger farming operations seeking larger agricultural banks. Finally, in aggregate analysis, changes in interest rates resulting from forces in national markets, public policy, and the general economy should become more prominent determinants of capital investment and productivity in agriculture.

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Impacts on Agriculture of Deregulating the Transportation System

Marc A. Johnson

The term "deregulation," used in reference to surface transportation, is a useful, one-word slogan representing a significant increase in commercial freedom for the transportation industries. However, the term does not imply an institutional shift from the current, regulated, common carrier structure to a completely unregulated, competitive market structure. When constructing the Staggers Rail Act of 1980 and the Motor Carrier Act of 1980, Congress had no intention to terminate surface transportation regulation. The intent was to loosen the grip of government rules, allowing carriers and shippers to respond more fully to opportunities available in an increasingly competitive market environment.

The purpose of this paper is to assess the likely effects of transportation regulatory reform on transportation opportunities of agricultural shippers and rural communities. This purpose requires consideration of three topics: (*a*) criteria for maintaining economic regulations, (*b*) tests of agricultural transportation markets against the criteria for regulation and (*c*) the legislated regulatory changes. This approach also will provide implications for the effects on agriculture of complete transportation economic deregulation.

Criteria for Regulation

Transport regulation in the United States developed along with public utility regulation. A public utility is considered an "essential" industry with a tendency toward monopoly. As such, utilities are publicly sanctioned and supported as virtual monopolies, protected from competitors in return for public-spirited service. The public utility approach has created a transportation system based on the protected common carrier, including all railroads and most for-hire motor carriers.

The common carrier structure is charged with raising rate levels above cost, distorting relative transport rates, creating associated resource waste and yielding miserably low productivity growth in the transportation industries (e.g., Caves, Christiansen, Swanson; Friedlaender; Levin 1978; Moore; Spann and Erickson; Stigler). However, proponents of regulation anticipate monopoly abuses in a free market structure. Criteria for maintaining regulations are discussed next to provide a test of these conflicting views.

Regulation is the exercise by the state of the power to prohibit or compel actions by persons or firms. Three theories have been developed inductively to explain why the state exercises regulatory powers. First, the public interest theory suggests that the state intervenes to protect the public from market power. Second, the public finance theory argues that the state finances "worthwhile" projects through cross-subsidy where the market otherwise would fail (Posner). Thus, criteria for maintaining transport regulation are to be found in market power and market failure. A third theory, capture theory, states that rent-seeking industries capture the coercive power of the state to protect cartel arrangements, i.e., to protect market power (Buchanan, Stigler). Capture theory is important because railroads and motor carriers have been identified as cartels protected by regulation (Moore, Spann and Erickson, Stigler). However, the theory offers no criteria for maintaining regulations.

Market Power

Market power in transportation may arise when only one feasible shipment alternative is available. This may occur in industries with decreasing long-run average costs where consolidations are continually justified or when

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traffic volume will support only one carrier, leaving shippers captive to that carrier (Seneca). Thus, criteria for regulation of market power are two: (*a*) evidence of decreasing long-run average cost over the relevant output range of transportation industries and (*b*) a lack of more than one shipper alternative for a significant number of shippers in the long run.

First, the decreasing cost hypothesis can be ruled out. Trucking has been shown to be a slightly increasing cost industry after accounting for capacity utilization factors (Koenker, Moore, Spady and Friedlaender). The minimum average cost of operation lies at an annual output level near six to eight million ton-miles, suggesting economy in trucking firms with 2 to 5 tractor-trailers. Economies in trucking come not from firm size but from the capacity utilization achieved with longer hauls and heavier loads. Strictly limited entry has left acquisition and merger as the only viable means to achieve longer hauls, thereby forcing mergers beyond efficient firm size to achieve economies of utilization (Spady and Friedlaender).

Whether railroading is a decreasing or constant cost industry is unclear from empirical studies (Harris). However, Spann and Erickson have shown that railroad firm behavior prior to the Interstate Commerce Act was not representative of a decreasing cost industry. Also, a recent empirical study reveals that railroads, like trucks, have an average cost which is largely determined by capacity utilization factors (Harris). Traffic density is a major determinant of average cost; operating a given amount of traffic over a larger network raises average cost.

While the decreasing cost criterion for regulation can be discarded, cost studies show clear efficiencies in capacity utilization. One should look for impediments to capacity utilization which represent barriers to achieving least-cost operations.

The second potential source of monopoly power is where either traffic density is low enough to support only one feasible carrier or access to more than one carrier is restricted. This is the "captive shipper" problem considered critical by some (Shaffer, Breimyer). The criterion for regulation in this case is the competitiveness of transportation alternatives. Competition is the lack of supplier control over price and is reflected in price elasticity of demand for freight services faced by particular transport firms.

Market Failure

The second motivation for regulation is to prevent market failure. This may occur if transportation is largely a public good or if transportation markets yield externalities.

Public goods are those which are nonexclusive in consumption and have zero marginal cost of production. Highways and waterways have problems with exclusion. But this is a user charge and taxation issue. There is no problem excluding shippers from the means of conveyance. The zero marginal cost criterion of public goods also is not realistic in transportation. Marginal cost in operations would be zero only in the case of persistent excess capacity, which would not occur in an uninhibited market (Johnson and Pasour). Thus, the public good criterion for regulation is irrelevant for the operating segments of transportation industries.

Externalities might be another source of market failure where transportation influences are (*a*) beyond the direct concern of carriers and shippers and (*b*) incapable of being accounted for by side contracts between carriers and indirectly affected consumers. Examples given of transportation externalities include local economic development potential, population settlement patterns, fuel conservation, and employment effects (Shaffer). The cross-subsidy approach to handling externalities involves two problems: (*a*) identification of a true externality and (*b*) the relative ability of a centralized agency to perceive costs and preferences.

Identification of a true, Pareto-relevant externality is not possible if one accepts the reality that transaction costs are nonzero in contract negotiation (Dahlman). Access to the ability to bargain allows carriers and consumers of indirect transportation products to consider the benefits and costs of a contract which would internalize the effects, e.g., a state highway department subsidizing a rail branch line to prevent road deterioration anticipated with traffic diversion to trucks. If the parties are free to negotiate and a contract is not struck, this implies not the persistence of externality but the inadequacy of anticipated benefits to cover anticipated costs of negotiation and carrying out a contract. Parties may make mistakes due to imperfect information, but this is a part of the entrepreneurial decision process. For an outside observer to identify a no-contract situation as evidence of persistent

Pareto-relevant externality is to say that the outside observer thinks he knows more about the risks, opportunity costs, and preferences of the participants than the participants themselves do. The roles of government are to establish initial rights and to insure the ability to bargain.

If the inability to identify externality were not enough, consider the relative ability of a central authority to accumulate enough information to solve one if found. A central authority must undertake considerable investigations to understand the situation and the interests involved in an indirect products case, and even then, be left incapable of accurately estimating opportunity costs and preferences (Hayek, p. 524). Also, having to start each case without prior knowledge of specific, local circumstances makes it difficult for a central authority to render timely decisions which permit rapid adaptation to constantly changing market environments.

The criterion for regulation to prevent market failure is the presence of market restrictions on bargaining between carriers and nonshippers. When bargaining is prevented, externalities may persist even in the presence of low transaction and operational costs.

The Criteria Applied to Agriculture

Three criteria for regulation have surfaced in the preceding discussion: (*a*) impediments to capacity utilization, (*b*) competitiveness of transportation alternatives, and (*c*) restrictions on bargaining. Agricultural transportation markets can be evaluated against these criteria by mode of transport. Opponents of "deregulation" have supplied two hypotheses: (*a*) that market barriers to entry and capacity utilization will leave rural communities without adequate truck service, and (*b*) that insufficient competitive shipper alternatives exist to protect agricultural communities from railroad monopoly behavior.

Rural Truck Service

There is evidence that rural communities are being served rather well by trucking services in spite of, rather than because of, common carrier obligations, and that market barriers to entry and capacity utilization are not as great as regulatory barriers. The experience of temporarily exempting fresh dressed and frozen poultry and frozen fruits and vegetables from truck regulation during the 1950s is an exemplary controlled experiment on the price effects of "deregulation" (reported in Moore, p. 59). During the period of exemption, truck rates on fresh poultry, frozen poultry, and frozen fruits and vegetables dipped an average 33%, 36%, and 19%, respectively. A recent survey of the exempt livestock trucking industry shows that service prices are very near USDA-budgeted cost estimates (Hoffman, Boles, Hutchinson). Despite near-cost prices, these firms had the following characteristics: an average life of eighteen years, average capacity utilization in a seasonal business of 94,000 miles per year per vehicle, and an economic average firm size of five tractor-trailers.

Free entry of firms into an industry encourages a competitive environment which affects service quality as well as prices. A recent survey of livestock shippers shows that shippers are generally complimentary of service quality; only 20% of the market has gone to private carriage (Boles). Based on several survey studies, Allen concludes that the quality of less-than-load service to rural communities is due chiefly to the fill-in services of the United Parcel Service and contract and private carriage rather than to the fulfillment of common carrier service obligations.

There appear to be neither economic nor marketing advantages which would give large, national carriers an advantage over local carriers in providing local, rural transportation services. In fact, free entry and removal of specific authority restrictions on commodities, routes, and service points will tend to create lower general rates, a broader variety of rate-service alternatives responsive to shippers' specific logistical demands, and enhanced capacity utilization (Johnson and Tyng; U.S. Senate, pp. 124–28).

Rural Rail Competition

The public interest view holds that railroads are regulated to prevent abuse from monopolistic practices. However, five categories of empirical studies provide strong evidence that there are close substitutes for the services of particular railroad companies, providing both intermodal and intramodal competition. These studies relate to evaluations of (*a*) rail line abandonments, (*b*) seasonal railroad rates, (*c*) rail-barge competition, (*d*) fresh fruit and vegetable rail demand, and (*e*) interrailroad competition.

The first group of studies evaluates the effects of rail abandonments on the grain economies of the Midwest and the Plains (Baumel, Miller, Drinka; Berglund and Anderson; Johnson; Larson and Kane; Tyrchniewicz and Tosterud). Although in a few cases portions of lines studied are marginally viable, the maximum abandonment alternative is usually the most efficient because there are less costly transportation alternatives. These alternatives include trucking, truck-rail and truck-barge combinations, and truck assembly at subterminals for subsequent unit-train shipment. These studies suggest that on rail lines of low density, cross-subsidy inherent in rail maintenance is the only force inhibiting economic adjustment of the grain collection and fertilizer distribution system. In fact, there is evidence that removal of regulatory protection on lines can stimulate adjustment and growth (Miller, Baumel, Narigon).

Seasonal railroad rate feasibility studies, conducted in Oklahoma and North Dakota, found that grain traffic would not be smoothed by seasonal rates because shipment alternatives did not permit rail rates to rise sufficiently to encourage additional storage construction (Shouse and Johnson; Wilson, Hvinden, Cosgriff). Both studies assume historical elevator patronage and uniform rail rate increases, prohibiting consideration of interrailroad competition. In Oklahoma, localized own-price elasticities of demand for rail services during the harvest period ranged from -1.02 to -3.7 (Shouse and Johnson, p. 23). In North Dakota, regional railroad demand is inelastic (-0.629) with an elastic cross-price relationship with truck service (Wilson, Hvinden, Cosgriff, pp. 37–39).

Railroad-barge competition is effective over a broad territory. The truck-barge alternative offers competitive rates (equal or below rail rates) for wheat shipment from the entire state of Kansas, except for the southwestern counties (Babcock, Johnson and Mennem). Barge competition also effectively limits rail rate increases for Kansas wheat moving to eastern flour mills, and truck competition limits rail rate increases for Kansas flour to numerous consumer markets (Babcock). In the Pacific Northwest, the price elasticity of truck-barge grain demand is estimated to range from -1.27 to -5.20, and cross elasticities of truck-barge demand with respect to rail rates are estimated to range from 1.46 to 5.30 (Logsdon).

Fruit and vegetable transportation studies on the West Coast also support the contention that competitive transportation alternatives exist for agricultural commodities. Truck and rail services demanded for movements of western fresh cherries and apples have modal demands which are own-price elastic with mutual cross-price elasticities with other modes which are positive and greater than unity (Miklius, Casavant, Garrod). Early evidence on the effects of exempting fresh fruits and vegetables from rail regulation two years ago shows that rail rates fell, rail volume and market share increased, and considerable railroad management activity has been devoted to creating rate-service options to compete in the cross-country fresh produce transport market (Manalytics, Inc.).

The last group of studies is the most convincing in support of the hypothesis that railroads face substantial competition in rural transport markets. A simulation of "deregulation" strategies applied to 1972 conditions and rates reveals the power of interrailroad competition to limit rail rate increases on agricultural products in the absence of maximum rate regulation (Levin 1981a, b). If rate restraints were removed without dismantling collective rate making, rail rates on field crops would climb 40% to 80% and produce rates would rise slightly. However, with a moderate degree of interrailroad competition, field crop rates would fall slightly and produce rates would plummet.

Two localized investigations reinforce the power of interrailroad competition to limit rail rate increases without regulation. Fuller and Shanmugham observe the effects of rail rate increases for wheat in western Kansas, Oklahoma, and Texas. When all railroads raise their rates simultaneously by 10%, arc price elasticities of demand for rail service in five subregions range from 0.0 to -4.4 (-1.47 for the region). However, when only the dominant railroad raises rates by 10% while other railroads and trucks hold rates and facilities constant, the own-price elasticity of demand for the dominant carrier ranges from -1.2 to -8.7 (-5.6 for the region); cross elasticities with respect to other railroad carriers range from 1.7 to 3.8 (2.9 for the region). In the long run, when river and port storage facilities can be expanded, a 10% rail rate hike would remove railroads from the market.

Case studies for corn and soybeans in eastern and western Iowa yield similar results (Miller, Baumel, Drinka). When corn and

soybeans are kept on the farm for marketing flexibility and all railroads raise rates 20%, farmer cost increases 6.8¢ per bushel in western Iowa and 3.6¢ per bushel in eastern Iowa. But when only the dominant carrier raises rates 20% while other railroads do not change rates, farmer cost increases are only 2.0¢ per bushel in the west and 0.7¢ per bushel in the east. In the latter case, own-price elasticity of demand for the dominant carrier is -4.0 in both Iowa regions and cross-price elasticities with respect to other railroads are 7.0 in the west and 3.5 in the east. The Iowa study suggests that with a flexible marketing strategy, farmers have the capacity to deliver grain to elevators located on railroads with the best rates. This is the source of interrailroad competition.

The preceding summary of evidence, generated in numerous independent investigations using a variety of analytical methods leads to the following conclusions regarding the criteria for regulation: (*a*) internal firm cost economies provide strong incentives toward maximum capacity utilization; and (*b*) competitively priced alternatives to local rail carrier service are broadly available. There likely will be specific instances where service will diminish in small communities and rail shippers will have to cease operations. However, there appears to be no strong evidence to justify maintenance of pervasive transportation regulation for agriculture. Specific complaints of monopoly behavior or discrimination can still be taken to the ICC, the Department of Justice, or the court system.

Regulatory Reforms

Preparations are now complete to evaluate the effects of transportation regulatory reform on rural communities. Regulatory reforms in transportation are chiefly contained in the Railroad Revitalization and Regulatory Reform Act of 1976 (4-R Act), the Staggers Rail Act of 1980, the Motor Carrier Act of 1980, and various initiatives of the ICC.

Motor Carriers

The Motor Carrier Act of 1980 focuses on reducing regulatory entry barriers. The act directs the ICC to streamline the common carrier certification process and to ease the criteria for approval. Fully certificated carriers must prove themselves "fit, willing and able" to serve and that they will serve a "useful public purpose," presumably much less strict than the "public convenience and necessity" standard. Protestors must be directly involved in the type of carriage proposed, and evidence of potential traffic diversion from existing carriers is no longer sufficient to prevent entry. Under expedited procedures, existing carriers can expand their authority to cover more commodities, intermediate delivery points, round-trip routing and larger territories; many specific routing and gateway restrictions are to be removed immediately. Mixing of contract and common carrier loads and exempt and regulated commodities in the same load is permitted to add loading flexibility.

Three motor carrier entry provisions are especially important for agriculture. First, cooperatives can haul up to 25% of tonnage from nonmember, nonexempt commodities, instead of 15%, which improves backhaul potential. Second, more agricultural inputs have been exempted from regulation, including animal by-products not for human consumption, livestock and poultry feed, and agricultural seeds and plants. Third, a new class of "fitness only" carriers has been established for those performing the following services: (*a*) serving a town recently losing a railroad or not served by a regular carrier, (*b*) hauling government property, (*c*) hauling small packaged freight and (*d*) owner-operators hauling food products, agricultural limestone and soil conditioners, and agricultural fertilizer. These services are presumed to fulfill the "useful public purpose" criterion, and applications will be reviewed only on the merits of the carriers' fitness to serve these functions. All three provisions provide flexibility for exempt and cooperative haulers to extend their seasons of operation and to organize backhauls to the country.

Previously, evidence suggested no appreciable market barriers to motor carrier entry or capacity utilization. New regulatory rules greatly reduce regulatory barriers to entry and capacity utilization. Now all classes of truckers can apply for, and expect to be granted, authority to haul the traffic for which they can compete in the market. City to country backhaul potential is much improved, especially for exempt haulers, with relaxation of access to food, feed, and fertilizer. Because truck costs are so sensitive to capacity utilization, eased entry can be expected to reduce trucking costs. Access to traffic and lower trucking

costs will enhance competitiveness within the agricultural trucking industry and place lower rate ceilings on railroads.

Railroads

The Staggers Rail Act of 1980 focuses on railroad-pricing flexibility and protection of bargaining channels. The act sets a minimum rate standard at variable cost and limits ICC jurisdiction on maximum rates to those cases where the railroad has "market dominance." A rate falling below a rate-to-variable-cost ratio threshold is sufficient to show a lack of market dominance. In shipper-initiated complaints, the burden of proof is on the shipper. Consequently, railroads are currently free to adjust rates in a considerable band. In addition, limited liability rates and rate premiums for special car services provide flexibility to construct rate-service options. Rate flexibility provisions already have been used to lower short-haul rates to meet truck competition and to lower long-haul rates for grain.

Three provisions are especially important for agriculture. First, two classes of carriage previously available to motor and water carriers are formally recognized for railroads: exempt and contract carriage. ICC initiative previously exempted fresh fruits and vegetables and piggyback shipments from regulation. Contracts make possible the direct negotiation of specific shippers and carriers for specific rate and service packages designed to shipper and carrier logistical needs.

Second, a pair of provisions stimulates interrailroad competition, previously shown to be very important in market rate control. One provision restricts the activities of rate bureaus preventing discussion and voting on single-line rates and, after 1983, discussion of joint rates by other than "practicably participating" carriers. Another provision establishes a quick procedure by which shippers can petition for reciprocal switching agreements between railroads. This means that shippers in two-railroad towns who are located on only one railroad can obtain access to both railroads with obvious competitive value.

Third, rail abandonment procedures are made speedier than previously, but more market options are made available to shippers and groups who truly value the line. These options included (*a*) carload surcharges on low-traffic lines, (*b*) rail-affiliated truck services to communities losing rail lines (previously truck allowances applied only to communities with rail lines), and (*c*) forced sale of deteriorating branch lines to local groups.

Previously, evidence showed that with moderate interrailroad competition, railroad rate freedom would not harshly affect agriculture, generally. Through rate bureau limitations and reciprocal switching agreements, interrailroad competition is enhanced. Rate flexibility can and is being used to enter new markets offering shippers savings. Contracts and exemptions open a new field of negotiated, tailored rate-service packages to shippers yielding enhanced capacity utilization for railroads and improved service for shippers. Shippers and local community groups are now allowed greater flexibility in bargaining directly with railroads on means to preserve local rail services where options were restricted before. Railroad regulatory reform offers many new opportunities for creative marketing and procurement in agricultural industries.

Conclusion

Transportation regulatory reforms represent opportunities for agriculture. As with any change of rules, there will be cases of individuals losing while others gain as a result of regulatory reform. But evidence does not reveal any fulfillment of the criteria for maintaining regulation in the agricultural transportation markets. These markets are competitive. Cost incentives encourage capacity utilization. The profit motive encourages entry and bargaining for service. Agriculture would be well served if remaining motor carrier entry restrictions and railroad rate limits were removed on a path toward true deregulation.

Regulation has been largely counterproductive for agriculture. A layer of restrictions on competitive market processes has been substantially removed; direct bargaining between firms promotes transmission of clearer market signals. "Deregulation" offers many opportunities for agricultural firms to adjust marketing and procurement strategies to reflect a greater range of transportation price and service options.

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Impacts of Regulatory Change on Financial Markets for Agriculture: Discussion

Dean W. Hughes

Peter Barry has done a good job of summarizing recent changes in legislation and discussing the impacts of these changes on the suppliers of agricultural credit. Therefore, I have only a few additional points to make regarding the impact of these changes on the sources of farm credit. I would then like to expand his analysis to discuss more fully their impacts on the farm sector.

Some Additional Market Changes

At least four recent financial innovations not mentioned in Barry's paper are having an impact on rural credit markets. The first is the introduction of financial futures markets, which should allow for some reduction in the anticipated growth in interest rate risks. The second is the emergence of a service provided by financial intermediaries wherein small banks' certificates of deposit are packaged to offer in the national money markets (Illingworth). This service will reinforce the other trends that Barry suggests will more fully integrate rural financial markets with the national economy. The third is that nonmember banks gained access to the Federal Reserve System's discount window with the enactment of the Depository Institutions Deregulation and Monetary Control Act of 1980. Such access may provide a source of credit to some nonmember rural banks that they have not had in the past. Finally, the rapid growth of money market mutual funds has decreased the flow of funds in rural credit markets over the last two years (Gramley). But in the future, as new equilibriums are established and alternatives evolve for rural banks to tap national money markets, this problem likely will decline in importance.

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The views expressed in this paper are the author's and do not necessarily reflect those of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

Impacts on the Farm Sector

Barry's paper suggests that there will be at least four substantial impacts of recent and anticipated legislative changes on rural credit markets including: (*a*) less quantity rationing (both in aggregate and on the individual loan level), (*b*) higher interest rates, (*c*) more variable interest rates, and (*d*) a decline in the importance of government lending.[1]

A decrease in fund availability problems at rural banks would decrease the likelihood that short-run changes in financial markets would have dramatic impact on the ability of farmers to produce food and fiber. It also would accelerate the concentration of the farm sector. If the laws on branch banking are significantly altered, local banks' capital and surplus limitations may impose fewer restrictions on the size of individual production loans. In addition, one of the automatic stabilizers of farm sector concentration will be removed. In past times of limited fund availability, agricultural lenders' priorities have been to make operating loans first and to postpone farm ownership loans. Thus, farmers deciding to quit during a time of credit rationing would have a difficult time finding buyers who could arrange mortgages. They might then produce for another year and later find their financial position improved. If, in the future, credit is rationed only by interest rates, those who are "creditworthy" (normally those who are already wealthy) will be able to borrow to buy the assets of exiting farmers at all times.

Higher interest rates in rural credit markets will require larger farm incomes. Highly leveraged operations will be faced with higher interest expenses. But the need for higher incomes will not be restricted only to farmers who rely heavily on debt financing. Higher

[1] These impacts are not predictions of the future, but differences caused by changes in legislation. For example, while interest rates may not increase above those currently faced by farmers, they will be higher in the future than they would be if the laws had not changed.

interest rates will be available on the alternatives to investing equity funds in farming, so the entire sector will have to be more profitable. Investment projects will have to be discounted by higher costs of capital, and therefore fewer may be accepted. All else equal, the subsequent slowing of the adoption of new technologies will slow the rate of increase in farm output and farm prices should increase.

An increase in the variability of interest rates can best be analyzed as an increase in financial risk (Penson and Lins, Gabriel and Baker). Two consequences are suggested by such analysis. First, farmers likely will want to reduce their borrowing to some extent. This will add to the slowing of adopting new technologies and may tend to depress the rate of increase in farm real estate values. Second, farmers may try to reduce their production risks. Marginally profitable land which is subject to unusual weather risks may be removed from production. And farmers will likely demand increased coverage from government and private insurance companies. The concentration of the farm sector also will be speeded up by these increases in risk. Large farmers with substantial equity buffers and wealthy nonfarmers will be more willing to accept the increased financial risks than small- to medium-sized farm owners who rely on farm income as their primary means of support.

A sudden reduction in government lending could have dramatic effects on the farm sector. Currently, the federal government holds over 12% of all farm debt. Any program that would rapidly decrease government lending would likely send many farmers into bankruptcy, reducing farm real estate values, and to some extent decreasing farm output. Even if the reductions occur more slowly, such that there is minimal disruption of production and real estate values, there will be an acceleration of the concentration of the sector and an increase in the risks of farming. The Farmers Home Administration (FmHA), the primary government lender to agriculture, must by law lend to farmers who cannot get credit elsewhere. Assuming, then, that their clients truly could not find credit from other sources, a reduction in FmHA lending will lead their borrowers to leave the sector. Because the vast majority of FmHA loans have been made to small farmers, any reduction in their role will increase average farm size (Hughes et al.). A decrease in the commitment of the government to lend to farmers will also increase the risks of farming in an ultimate economic sense. There likely will be an increase in farm failures in coming years as the accumulation of farmers who have been "bailed out" by FmHA over the last few years are allowed to leave the sector. Some normal failure rate probably will then be reasserted.

Conclusions

With few exceptions, Barry's paper does a good job tracing the impacts of recent regulatory changes on the institutions that supply credit to the farming sector. Simple extensions of his analysis suggest that the farming sector itself will be affected in several ways. It is likely that the deregulation of rural financial markets will speed the movement to a more concentrated farming sector. In addition, the adaption of new technologies probably will be slower than otherwise would occur. Farming will need to be more profitable to justify continued investment and to offset anticipated increases in financial risks. And finally, farm output likely will grow more slowly and farm prices increase more rapidly than would be expected if no change in banking regulations had occurred.

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Impacts on Agriculture of Deregulating the Transportation System: Discussion

Jerry E. Fruin

I concur with the general conclusions of Johnson's paper. Transportation deregulation was long overdue. Regulation was ineffective and, in some instances, counterproductive to agriculture, rural communities, and the regulated carrier. There will be individual losers as adjustments are made to less regulation, but the total result for agriculture will be positive. However, I have several reservations about the overall thrust of rail deregulation.

Johnson states two justifications for regulation of the transport industry. One is the need for the cross-subsidization of services that the transport firm could not or would not otherwise supply. The other is the argument that the state must protect the public from the market power of the industry. Two examples that the opponents of deregulation use to show that agriculture and rural communities require transportation regulation are then discussed. These are *(a)* that market barriers to entry will leave rural communities without adequate truck service, and *(b)* that insufficient competition exists to protect agriculture from railroad monopoly behavior.

With regard to truck service to small communities, he concludes, and I fully concur, that "free entry and the removal of specific authority restrictions on commodities, routes, and service points will tend to lower rates, improve service, and enhance capacity utilization." The barriers to entry for trucking came more from the regulatory requirements than from market barriers. The Motor Carrier Act of 1980 removed many of these restrictions. The act will have little impact on agriculture and rural communities, and the impact that it does have will be positive. That is also true for airline and intercity bus deregulation. The airways and highways are publicly owned, and freedom to enter a market can provide competition. Rail is different. The roadbed is privately owned. That provides monopoly power.

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Will sufficient competition exist to protect agriculture from railroad monopoly behavior? Johnson concludes that although there may be some harm, there is no strong evidence to maintain transportation regulation for agriculture. He cites a number of studies to back his conclusions, but each addresses specific issues and not the total deregulation package. That package went much further than thought possible two years ago. Consequently, rail deregulation may have gone too far.

I agree with the rail abandonment studies that conclude that the maximum abandonment case is most efficient considering the economic variables studied. However, I am not convinced that the distribution of the economic returns will be equitable. How much of the savings will stay in the rural areas? What will happen to land values 40 miles or more from a subterminal? Will subterminal ownership become controlled by the limited number of regional or national firms that have the access to the capital required to build train-loading facilities and the market power to negotiate favorable contract rates? Do these studies adequately account for the cost of maintaining our road network as grain is moved longer distances to subterminals and the vehicle mix and routes traveled change?

The Staggers Act did not leave the ICC and the states enough discretion on abandonments. There still is no master plan with hard decisions on abandonment versus the rehabilitation of marginal lines. The last branchline in an area frequently will have operating profits after competing branches are abandoned if it is rehabilitated at railroad or public expense, but the ICC cannot force a sensible rationalization of the rail system.

Some of the studies center on interrailroad competition holding down rates. But, will we really have effective interrailroad competition in 1990 with only six or eight major rail systems? Mergers as a method of rationalization are encouraged by the Staggers Act, but we

can no longer be assured of open gateways and joint rates as in the past. Rather, surcharges and combination rates may become the rule. Some of the railroads will have monopoly power over larger areas than envisioned in these studies. We cannot count on barge transportation being as effective in holding down rates in the future. Waterway user charges have been legislated and are now in place. Currently, they have little or no effect on barge-rail competition. However, if full cost recovery is legislated, rails will gain a cost advantage over large areas.

A key feature of the Staggers Act is the legalization of contract rates and the release of the railroads from their absolute common carrier status. Although a number of safeguards were included for agricultural shippers, the end result is that a railroad is free to discriminate, i.e., choose whom it will sign contracts with. These contracts could give a limited number of shippers low-cost volume rates while others pay higher single-car rates. These contracts, once approved, cannot be appealed to the ICC. Clearly, there will be increased concentration in the grain-marketing channel. Time will tell if this is good or bad for agriculture.

An important implication of deregulation for agriculture and for the national economy was not discussed. The combination of rate-making freedom and contract rates will destroy the existing railroad rate structure in the United States. Furthermore, the loss of antitrust immunity for rate bureaus (with which I agree) will preclude such a rate structure from being reestablished. Much of this value-of-service based railroad rate structure is over 100 years old, having roots that predated the ICC. This structure includes provisions like transit rates and port equalization differentials. It had tremendous stability because of precedents established in ICC hearings and supreme court decisions. It was reinforced by protests from affected constituents when even minor changes were proposed. Such stability hindered locational and technological adjustments. For example, there is general agreement that the transit privilege slowed the relocation of the grain processing industries.

The big changes for agriculture resulting from the destruction of the old rail rate structure will be in changed cost and locational advantages for food processing and manufacturing. Consider the impact of changes in the rate structure for sugar on the optimal locations for industries like baking, canning, and confectionaries and soft drinks. The existing structure was defined by the ICC Sugar Cases of 1922 and 1933. This rate structure was designed to "equalize" competition in the Midwest between cane sugar refiners in East Coast ports, New Orleans, and San Francisco, and to allow them to compete with domestic sugar beet refiners. Most of the cane sugar was, of course, from Cuba. This rate structure survived the Great Depression, sugar rationing, consumer acceptance of beet sugar, Castro's takeover of Cuba, and the development of the 120,000-pound airslide car.

The basic rate relationships of the 1933 ICC proceedings were that rates for a hundredweight of sugar shipped from New Orleans or Baltimore to Chicago were equal, the rate per 100 pounds from Philadelphia to Chicago was 1¢ more than from New Orleans, and from New York to Chicago 3¢ more.

Although the sugar rates from New Orleans and Baltimore to Chicago almost tripled from 34¢ to 95¢ during the forty years from 1933 to 1973, the differentials remained unchanged. It still cost only 3¢ more per hundredweight to ship sugar from New York to Chicago than from New Orleans to Chicago. This did not happen by accident. The ICC responded to industry protests each time there was a general rate increase and set the maximum rate increase for sugar equal to the increase from New Orleans to Chicago. The promotion of competition, if it ever did exist, evolved into protectionism.

These rate relationships caused sugar consumers on the East and West Coasts to subsidize midwestern sugar consumers, and caused sugar-using industries such as candy to locate in the Midwest rather than in the coastal sugar-refining centers.

The justifications for low sugar rates from the East to the Midwest center on Mississippi waterway competition. I was always puzzled over that because the commercial barge lines will not even consider hauling sugar. However, I recently found this quote by McPherson (pp. 371–2): "The railroads point out that the suger rates cannot be made higher to the cities on the Mississippi and Ohio Rivers, as they are now at the limit above which the boats would take the traffic." Note the use of the term "boats," not "barges," as that was written in 1909. Also, I have been collecting rates for a sugar substitute, fructose, from Minnesota to locations including Baltimore,

Interrelationships between Spot and Futures Markets: Some Implications of Rational Expectations

Joe H. Dewbre

The view that futures contract prices for storable agricultural commodities are rationally held expectations of subsequent cash prices has been widely accepted since Holbrook Working first explained commodity market intertemporal price behavior in these terms in 1958. Subsequent analyses by Brennan, Weymar, Tomek and Gray, and others adopted and extended Working's interpretation. Yet, despite its acceptance, implications of the rational expectations view have been all but ignored in econometric modeling efforts directed at explaining and predicting intertemporal price relations.

The purpose of this paper is (*a*) to propose an econometric modeling approach that recognizes the role of rational expectation formation in joint determination of commodity cash and futures prices, and (*b*) to explore the implications of such an approach for the following issues:

(*i*) the direction and magnitude of changes in cash and futures prices occurring in response to changes in economic information, and the direction of causality between cash and futures prices; and

(*ii*) the function of futures markets as agencies for forecasting price and the probable forecasting performance of futures contract prices.

Some issues addressed here have implications for all futures traded commodities. The arguments presented, however, relate most clearly to storable, continuously inventoried commodities. The nature of storage behavior and, thus, the relation between cash and futures prices for some commodities—livestock in particular—has not yet been resolved satisfactorily, but these issues are not addressed here.

Working's theory of anticipatory prices (1958) asserts that decisions on cash and futures prices take into account all available and relevant information concerning historical relationships as well as current and expected supply-demand conditions. According to this theory, the current period futures price for a contract maturing in time $t + T$ is the current market expectation of the subsequent cash market price in $t + T$.

With only slight modification, this interpretation can be considered equivalent to the more current "rational expectations" or equally redundant "efficient market" hypothesis. Formally stated, the rational expectations hypothesis (Muth's extended version) asserts that expectations of individual market participants (the subjective probability distribution of price outcomes) tend to be distributed for the same information set about the predictions of the theory (the objective probability distribution of price outcomes). In another interpretation it is simply asserted that economic agents use the appropriate economic model in forming their expectations of future prices. If valid, this latter interpretation has clear implications for the construction of econometric models of futures traded commodities. To explore these implications, we posit a model which assumes rational expectation formation.

An Econometric Model of Cash and Futures Price Determination: A Rational Expectations Approach

The model described here consists of only three equations: a current period commercial demand for stockholding, a current period

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aggregate consumption demand relation, and a market clearing identity equation. The equations are conceptualized and are to be estimated in monthly frequency. The logic of each demand equation is discussed briefly, with most attention devoted to the stockholding relation. Some of the ideas are then simplified in a graphic representation of the model, followed by some inferences.

Commercial Stockholding Demand

The dual role of stocks in markets characterized by seasonal production and stockholding tends to complicate the process of modeling such markets. On one hand, current period demand for stocks is usually the major component of current period demand for a given commodity. On the other hand, during most months, beginning-of-period stocks constitute the only source of supply. In this formulation, demand for stocks (supply of storage) depends upon the expected return to storage—the difference between expected future cash price and current period cash price—adjusted for expected storage costs. Expected storage costs, as defined here, consist of opportunity cost on the per unit value of the inventory commitment plus the physical outlay for space rental, insurance, and handling charges. The stock demand equation is presented in functional form below:

$$(1) \qquad Q_t^H = f_1[E(P_{t+1})_t - P_t - C_t],$$

where

$$\frac{\partial f_1}{\partial E(P_{t+1})} > 0, \ \frac{\partial f_1}{\partial P_t} < 0, \ \frac{\partial f_1}{C_t} < 0,$$

and where Q^H is the current period demand for stocks, $E(P_{t+1})$ is cash price expected to prevail in period $t + 1$—current period futures quote for a contract expiring in period $t + 1$, and C_t is one period storage charges—space rental, insurance, handling, and interest charges.

Assuming that current period futures prices represent unbiased market expectations of future cash prices, observed values of futures quotes can be plugged into the above equation for estimation purposes. With other factors being held constant, the demand for stocks is an increasing function of the difference between expected future cash price and current period cash price. Notice also that, consistent with usual requirements for demand functions, the slope of the relationship between demand for stocks and current period cash price is a negative one. Conversely, consistent with the usual requirements for supply functions, the slope of the relation between expected future period cash price and demand for stocks (supply of storage) is a positive one.

Aggregate Consumption Demand

A complete model of consumption demand would include separate equations for each component of current period consumptive demand, e.g., food, feed, and export for grain commodities. For simplicity's sake, the consumptive demand function used here represents an aggregation of these separate demand equations into only one equation. In practice, this would be accomplished by simply adding the separate consumptive demand equations together and then collecting terms. The result would be an equation with total current period quantity demanded on the left-hand side and, on the right-hand side a large number of variables representing current period prices of the commodity in question, of substitutes in feed, food, and export uses, and of commodities which use grain as an input (e.g., livestock). Other variables would measure incomes, exchange rates, other purchasing power indexes, and so on. Labeling all variables except current period quantity demanded and current period price of the commodity in question as Z_1 to Z_N, this equation would appear as

$$(2) \quad Q_t^D = (P_t^{b_1} Z_{1,t}^{b_2} Z_{2,t}^{b_3}, \ldots, Z_{N,t}^{b_{n+1}}),$$

where

$$\frac{\partial Q_t}{P_t} < 0, \frac{\partial Q_t^D}{Z_{i,t}} \lesseqgtr 0, \text{ and}$$

where Q_t is current period aggregate consumption demand, P_t is current period cash price, and $Z_{1,t}$–$Z_{n,t}$ are exogenous variables influencing consumption demand.

Market Clearing

Under the presumption that production is exogenously determined, as would usually be the case within any particular crop year, the final equation in this "mini" model is the standard market-clearing identity or price determination equation:

(3) $Q^{H} = Q_{-1}^{H} + Q_t^P - Q_t^D,$

where Q_t^P is production in period t.

Nothing has yet been said about how $E(P_{t+1})$, the price expectations variable which appears in the stock demand equation, is to be determined. In most commodity models, expected price is some kind of average of recent past prices, either a naive projection of last period's price or some form of adaptive expectation usually based upon a time series of price. Blakeslee incorporates a next year's loan price into an adaptive price expectations formulation. His approach allows an adaptively determined price expectation to be modified by one piece of information about the future—next year's price support loan rate. Houck and Subotnik model the determination of one-quarter-a-head futures prices within the same model that produces current quarter cash prices. Their formulation excludes altogether any consideration of expectations about the future; futures prices in their model are determined exclusively on the basis of current period supply-demand conditions.

These approaches seemingly would deny the rational expectations or anticipatory prices hypothesis which holds that prices (both cash and futures) reflect all publicly available economic information that bears upon their determination. More to the point, these approaches are inconsistent with observed market behavior. It has been shown that information concerning future supply-demand conditions does indeed influence current period cash prices (Pearson and Houck).

In this application, the price value that would be obtained by solving the posited model for the appropriate forward period is used to represent current expectations of that period's price value. A literal interpretation of the rational expectations hypothesis would have commodity market participants deriving expectations of future price as if they were actually solving a model like the one described above for the appropriate future period. In a very literal way this would require market participants to plug into each equation forecasts of each exogenous variable and then solve the complete model for the values of future price and other endogenous variables for the expectation period. Of course there is no requirement under a rational expectations view that market participants actually employ this forecasting procedure, but only that the expectations which they derive be consistent with those that would be obtained by using the model.

In order to draw some conclusions, it is helpful to review the ideas thus far presented in graphic form. Panels A and B (lines CD_1CD_1, D_1D_1, S_1S_1 and FCD_1FCD_1, FD_1FD_1, FS_1FS_1) of figure 1 present an initial equilibrium solution for the model for both a current and a future period. Looking first at panel A, the line CD_1CD_1 represents the current period aggregate consumption demand equation (2) drawn under the assumption that all variables except price are held constant. The line D_1D_1 represents the total of equations (1) and (2), where the difference between CD_1 and D_1 is current period stock demand. The current period supply function is shown as a perpendicular line reflecting the fact that supply available for any single current period is wholly predetermined. In most months this supply will consist entirely of stocks carried forward from the previous period, but even in those months in which production becomes a component of supply, it does so independently of price.

In order to graph the future period consumption equation (panel B, line CD_1CD_1) in the current period it is necessary only to plug in forecast values for future period $t + T$ for all exogenous variables $Z_1 \ldots Z_N$, appearing in the consumption equation (2), and then solve the equation at alternative levels of expected future price. The graphs of the other two lines are not obtained quite so simply. Considering future supply FS_1 FS_1 first, notice that it has some slope with respect to price. This occurs even if the forecast period is too short for a production response to price. This is because expected future supply consists of both expected future production and expected future beginning stocks; but expected future beginning stocks depend directly upon current period ending stocks, which by equation (1) are positively related to expected future price.

Graphing the stock demand function for some future period is made more difficult because doing so requires *ex ante* knowledge of what price expectations in the period $t + T$ will be for an even more distant future period $t + T + 1$. The obvious answer that this would require solving the model for period $t + T + 1$ only begs the question since this, in turn, would require *ex ante* knowledge of expectations of future price for some more distant horizon $t + T + 2$, and so on. One way of dealing with the problem is simply to extend the forecast horizon far enough into the future so that, because of discounting, any change in the level of expected price for the terminal

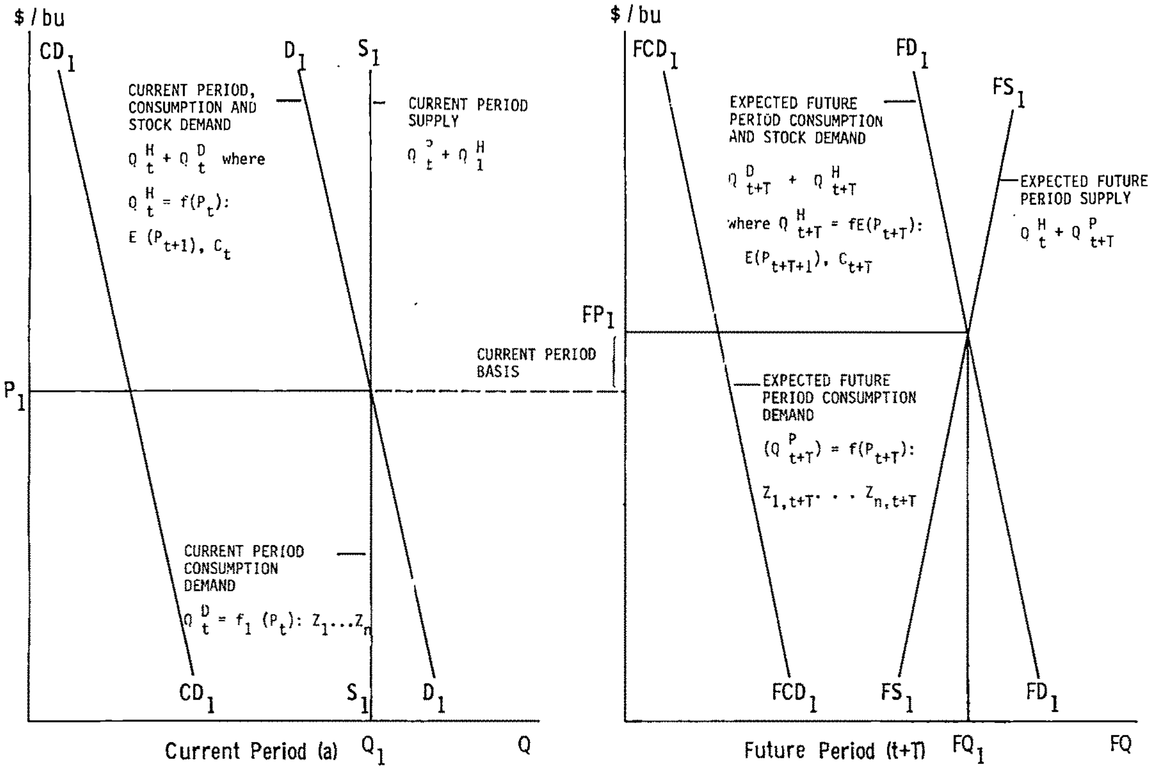

Figure 1. Initial cash and future period equilibrium

period has only a minor effect on any period within the forecast horizon of interest. The problem is resolved here by assuming values for these so-called "terminal" expectations of future price for the $t + T + k$th period. The choice of values for these assumptions is necessarily an arbitrary one, but there are some logically appealing alternatives. For example, forecasts of future agricultural production and prices are published routinely by the U.S. Department of Agriculture (USDA) and other public and private agencies. There is also the notion of a long-run "equilibrium" or normal price. This normal price probably is determined more by the relative (long-run) costs of producing the commodity in question versus alternative commodities than by the near-term stock considerations which so dominate price determination in the model posited here.[1]

It is now possible to trace the effects that changes from the initial equilibrium represented in figure 1 have on current and future period price and quantity outcomes. Figures 2 and 3 show the same initial equilibrium as was shown in figure 1—lines CD_1CD_1, D_1D_1, S_1S_1 in panel A and FCD_1FCD_1, FD_1FD_1 and FS_1FS_1 in panel B—and two alternative final equilibrium solutions obtained by assuming first an increase in expected future period production (figure 2) and second, a decline in current period interest rates (figure 3).

In this model, the causal chain which results in the "final" solution shown in figure 2 proceeds as follows. First, the increase in expected future production is translated into an increase in expected future supply which produces a "first-round" expected future price decrease. Since expected future price is a shifter in the current period stock demand equation, the decrease in future period expected price produces a leftward shift in current period demand for stocks, and a consequent round-one decrease in current period price. This decrease in current period price stimulates an increase in current period consumption and a falloff in current period carryout. The process does not stop here, however, since the decrease in current period carryout

[1] In this application, a forecast of this long-term normal or equilibrium price is to be modified simultaneously with model solutions across near-term forecast horizons. This is to be accomplished by adjusting a forecast of price produced by an annual model for end of crop year stocks generated by the posited short-term model.

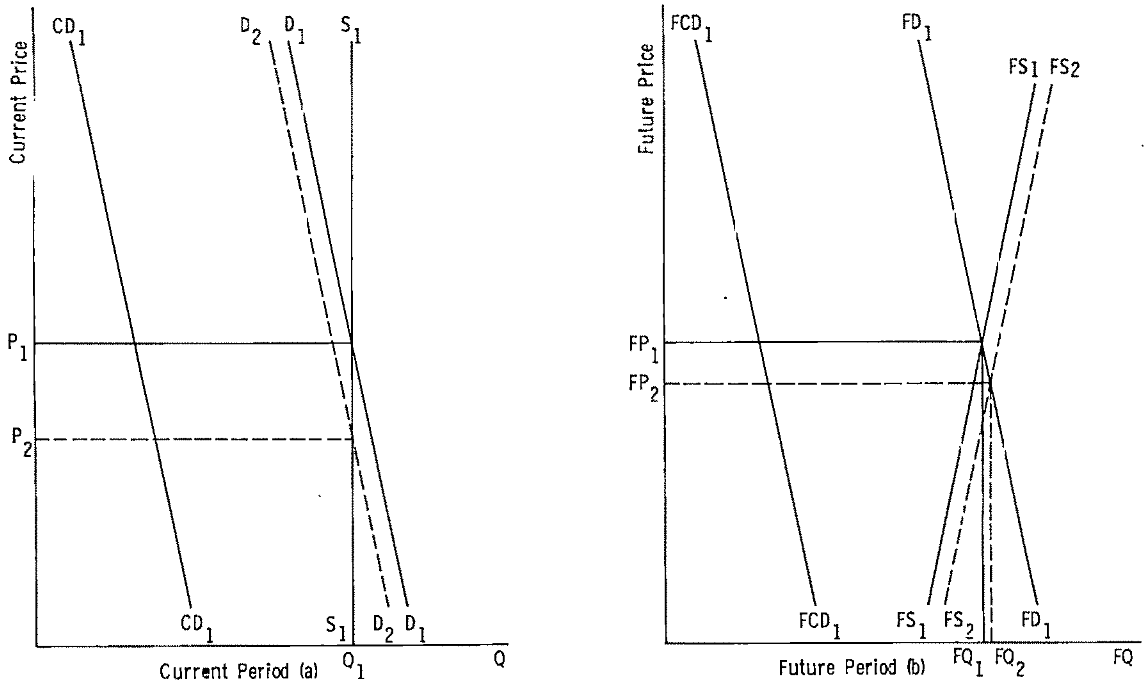

Figure 2. Impact of increase in future period crop expectations upon current cash and futures price

shows up as a decrease in future period supplies. This moderates the round-one future price impact, which in turn moderates the current period stock demand, and so on until the final equilibrium situation, $P_2FQ_2FQ_2$ shown in the figure 2, is obtained.[2]

As an additional example, consider the impact of a current period decline in interest rates, which is not accompanied by a change in expected future period interest rates (figure 3). This impacts initially by reducing storage costs and thereby increasing current period demand for stockholding. This causes a first-round increase in current period price and a rightward shift in future period supply (the increase in stocks carried out of the current period), which results in a corresponding decrease in future period price. The first-round decrease in future period price moderates the initial increase in current period stockholding demand, and thus the first-round increases in current period price as well, and so on until the final equilibrium $P_2FP_2FQ_2$, shown in figure 3, is obtained. Notice that in this final equilibrium, current period cash prices are higher while current period future prices are lower than in the prior equilibrium.

[2] Econometric model solution procedures that correspond to this kind of equilibration are somewhat different from conventional procedures. Anderson and Fair provide good discussions of how standard model-solving routines can be modified to accommodate a rational simulation approach. For readers familiar with standard Gauss Siedel iterative model solution programs, the problem essentially involves creating an outer iterative loop in which the model solves iteratively across entire forecast horizons in a manner analogous to iterative loops within individual forecast time periods.

Inferences

There are two major inferences with respect to the interrelation between cash and futures prices which, under a presumption of rational expectations, differ from conventional views. One of these concerns the way in which futures and cash prices fluctuate in response to changes in economic information, and the other concerns the forecasting performance of futures markets as they have been conventionally evaluated.

Direction and Magnitude of Changes in Cash versus Futures Prices

It is commonly held that changes in information concerning future supply or demand will, for storable agricultural commodities, produce equivalent or nearly equivalent changes in

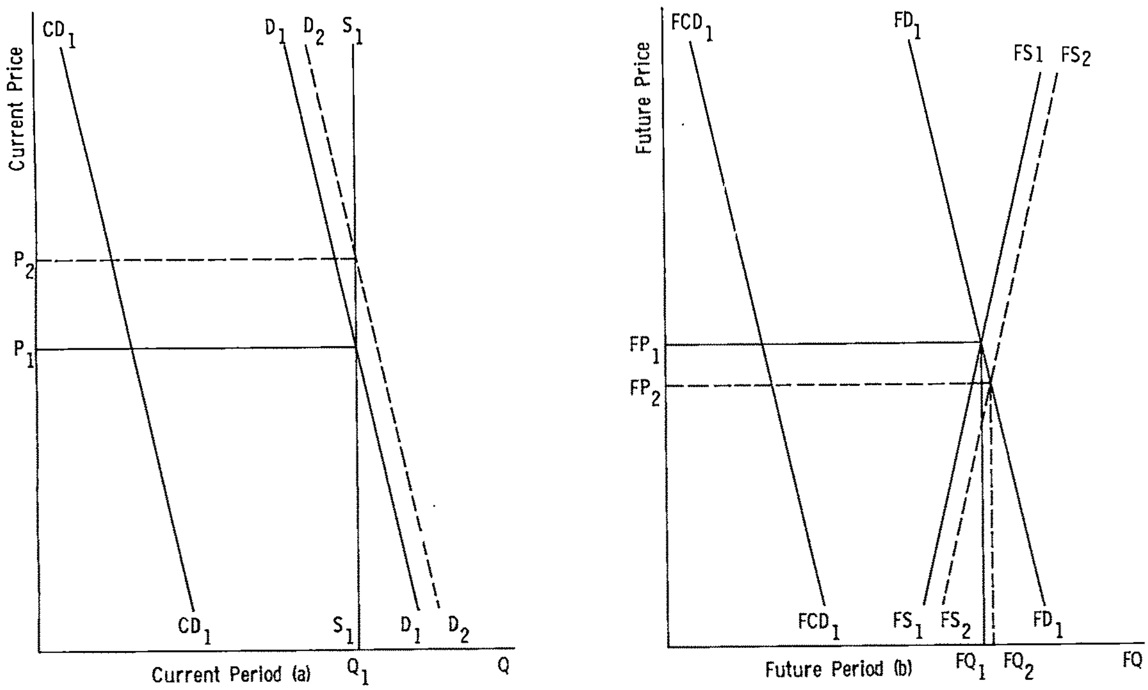

Figure 3. Impact of decrease in current period interest rates upon cash and futures prices

both cash and futures prices. These conclusions can be drawn using either of two frameworks of economic analysis—the supply of storage framework or the intertemporal-interregional price equilibrium framework.

In its usual interpretation, the supply of storage theory asserts that there are two more or less independent components to intertemporal price relationships. The first is the overall level of both cash and futures prices, which moves up or down in response to changing actual and expected supply-demand conditions. The second is price difference or "basis" relations between cash and futures prices and between individual futures prices. According to the usual view, the latter component of cash and futures price relationships, the basis, is substantially determined for any point in time by the level of actual inventories and costs of storage at that point. Working (p. 1255) states, "So far as supplies are concerned, it is only supplies already in existence which have any significant bearing on a current intertemporal price relation." One implication of this interpretation is that changes in expectations concerning future supply or demand conditions produce their price effect exclusively through a shift in the overall level or constellation of intertemporal price relations, leaving price difference or basis relationships unchanged (see Working 1949). That is to say, because of stockholding, any change in expected future supply or demand produces a change in current period price that is approximately equal to the corresponding change in expected future period price.

One can reach equivalent conclusions concerning changes in cash versus futures prices using the familiar intertemporal (or interregional) equilibrium framework (see, for example, Kenyon and Cooper). In this framework, prices for two markets separated in time or geographically, but in which storage (or trade) is permitted, will be in equilibrium when the price difference between them just equates with storage (or transportation) costs. In this model, changes from initial equilibrium in either expected quantities or storage costs will always produce exactly the same changes in both current and future prices.

Both of the above-mentioned theoretical frameworks are widely accepted and have guided much economic modeling. However, if one accepts the rational expectations arguments detailed in this paper, then the usual conclusions concerning the magnitude and

direction of changes in cash versus futures markets are invalid.

Given changes in economic information about the future simply need not produce equivalent changes in both cash and futures prices and, in fact, would be expected to do so only rarely. Clearly, the relative impact that a change in information about the future has on cash and future prices will depend on the time horizon of the information (discounting), the nature of the change (whether it is a change in a component of future demand or of future supply), and upon the relative elasticities of current versus future period supply and demand. Indeed, under quite plausible assumptions about particular changes in information, even the direction of change in cash prices may differ from that for futures prices. The interest rate decline traced in the previous section provides one example.

A related issue concerns the direction of causation between commodity cash and futures prices. The issue of whether futures prices cause or lead cash prices has been at the heart of much of the controversy over futures markets. It is clear from this treatment that causal chains which produce changes in cash and futures prices can run in either direction, depending on the kind of economic information initiating the change. For example, a change in information concerning future period consumption demand (such as an announcement of a trade agreement) would produce its effect on current cash prices through a causal chain initiated by a change in future price. Alternatively, a change in current period consumption demand produces its effect on future price through a causal chain initiated by a change in current period price.

Forecasting Performance of Futures Market

The forecasting performance of commodity futures markets has been the subject of much recent empirical analysis. Results reported in Leuthold, Leuthold and Hartman, and Martin and Garcia pose serious doubts about the accuracy of current period livestock futures contract prices as predictors of subsequent cash prices.

These analyses are all apparently predicated on the questionable assumption that an appropriate test of futures market performance is ability to forecast the future accurately. It is argued here that a more appropriate question is the same one that must be asked of an econometric forecasting model: "Are price changes which occur in futures markets (or are simulated by an econometric model) in response to changes in economic information consistent with economic theory?"

What can be said about the probable predictive performance of current period futures market quotes? One implication of the rational expectations view is that, since for any given point in time futures prices reflect all publicly available information, observed changes in prices (cash and futures) through time are due exclusively to unanticipated changes in information. Further, since over time such information becomes available randomly, the resultant observed price changes are random (serially uncorrelated). It follows directly that forecasts of future cash price taken from the futures market are unlikely to be very accurate for anything but the shortest time horizons. Furthermore, the longer the forecast horizon, the more time is allowed for randomly occurring changes in information, and the poorer are such forecasts likely to be. Thus, empirical results which appear to confirm this, such as those reported by Leuthold and Hartman and Martin and Garcia, can hardly be taken as an indictment of futures markets.

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Interrelationships between Monetary Instruments and Agricultural Commodity Trade

Robert G. Chambers

During the last decade agricultural economists have devoted increasing attention to the macroeconomic aspects of agricultural problems. Indeed, a recent presidential address to the American Agricultural Economics Association (Tweeten) centered on the macroeconomics of agriculture. Given the currency of the monetary approach to macroeconomics, it is not surprising, therefore, that there is also a growing interest in the effects of monetary instruments and monetary phenomena on agricultural commodity trade. In this paper I shall discuss what I feel are some of the most pertinent issues that researchers must address in this area. Before we proceed too far with our discussion, it is important to define what I mean by a monetary instrument.

Perhaps arbitrarily, I reserve the term "monetary instrument" for those macroeconomic variables which are primarily determined within domestic or international monetary markets. Obvious examples are the level of the money supply, interest rates, and exchange rates. I justify the term instrument by noting that as far as the agricultural sector is concerned these variables are, by and large, predetermined. For example, the levels of the money supply and interest rates in the United States are to a large extent determined by the policy of the Federal Reserve. Similarly, the price of the currency—the exchange rate— is ultimately determined by the demand and the supply for the currency and thus at least partially by governmental policy.

The first step in any attempt to outline research needs and goals is an identification of what has been done in the past. Although the literature on the macroeconomics of agriculture is fairly large and rapidly expanding, Eckstein and Heien, Lamm, Schuh (1976), and Tweeten are important examples, relatively little attention has been given to the effect of monetary instruments on agricultural trade. What attention has been given to this area of research has revolved mainly around the role of exchange rates in determining agricultural exports and prices. Thus, it is logical to start our discussion with a brief survey of the literature on exchange rates and agriculture.

Previous Investigations

Like most relatively new areas of research where there is not even a common agreement on what are the important problems, the relationship between exchange rates and agricultural trade has been the subject of a somewhat controversial literature. Schuh (1974) was among the first to suggest that the magnitude of the exchange rate could have important implications for agricultural trade. He suggested that maintenance of an artificially overvalued dollar for much of the postwar period had depressed U S. agricultural production, exports, and prices while artificially boosting the domestic demand for U.S. farm products. The argument behind Schuh's paper was simple and to the point; the maintenance of an overvalued dollar made U.S. agricultural exports relatively unattractive abroad. By artificially dampening overall demand for agricultural commodities, the exchange rate policy of the United States induced not only a lower level of agricultural exports but also lower domestic agricultural production.

Following Schuh's article, there appeared a series of theoretical and empirical studies on the effect of exchange rates on agricultural commodity trade (Grennes, Vellianitis-Fidas, Greenshields, Kost, Bredahl, Bredahl and Womack, and Chambers and Just 1979). The

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general tenor of several of these papers was that the importance of the exchange rate may have been overlooked for a long time, but past negligence should not be an excuse to overemphasize its current importance. Given the number and variety of these papers, it is impossible to do them justice within the confines of this presentation. What was (and remains) important is that they represent serious attempts by agricultural economists to investigate in detail the relationship between truly monetary variables and agricultural commodity trade. Remember that prior to 1973 the official U.S. exchange rate was a monetary instrument in the truest sense. It could be raised or lowered by the U.S. government. In fact, much of the original interest in the exchange rate followed President Nixon's decision to devalue the dollar in 1971.

By the time agricultural economists concerned themselves with the exchange rate, it was no longer a monetary instrument in the purest sense. In late 1973, the United States adopted a floating (albeit dirty) exchange rate system. Thus, much of the discussion on the relationship between the exchange rate and agricultural trade now centered on what actually happened after the United States devalued in the early 1970s. As is usual with economists, each party to the discussion had its own version of the truth and, in retrospect, perhaps too much time was spent arguing about the theoretically plausible size of the effect of the devaluation on agricultural commodity trade. Altogether too little time was spent on the next logical step in the progression—the investigation of the effect of the current determinants of the floating exchange rate on agricultural commodity trade.

Researchers acquainted with the literature on balance of payments and exchange rate analysis know that this next step was not easy since even experts in balance of payments analysis do not agree on the most appropriate method for modeling exchange rate determination. However, the then recently nascent monetary approach to the balance of payments and exchange rate determination suggested an important direction of further re- identity of the balance of payments with the difference between the demand for and the supply of a currency. If there is excess demand for a currency, then there exists a positive balance of payments; excess supply implies a deficit. The monetarists, therefore, argue that since the balance of payments is essentially a monetary phenomenon, it is best and most easily explained in terms of money and asset markets. If the exchange rate is functionally related to the payments situation of a country, then the monetary approach would suggest that the exchange rate is best explained by monetary phenomena.

Shei appears to have been the first to attempt a thorough investigation of the effect of monetary phenomena on U.S. agriculture. In his doctoral thesis, he constructed a compact, empirical, general equilibrium model of the U.S. economy. The model was simulated to investigate the impact of the money supply and the exchange rate on the agricultural sector of the economy. Shei's results indicate that the money supply has more important effects on U.S. agriculture than the exchange rate. Unfortunately, even though Shei's overall model was general equilibrium in nature, he treated the exchange rate as predetermined. Thus, a potentially important component of the adjustment process—the causal linkage between the money supply and the exchange rate—was ignored.

Chambers and later Chambers and Just (1981) developed empirical models of the interaction between the level of the money supply and the agricultural sector with an endogenized exchange rate. In point of fact, the exchange rate determination process provides the only direct link in the models between the level of the money supply and the agricultural sector. Thus, while a shortcoming of the Shei model is overcome in these studies, it must be recognized that they are less thorough in the specification of other potential linkages than the study by Shei.

Using dynamic multiplier methods on their empirical models, Chambers and Just (1981) estimated that the long-run elasticities of wheat, corn, and soybean exports with respect

little doubt that their results would be altered if a more complete set of linkages were specified. The Chambers and Just model also contains a significant nonlinearity which had to be replaced with a Taylor series approximation to permit multiplier analysis. Hence their results represent local approximations which might not be valid over a wide range of sample values.

Quite recently, Barnett, Bessler, and Thompson have completed an empirical examination of the causal linkage between the level of the U.S. and international money supplies and a variety of agricultural prices. This work is impressive in that it represents, to my knowledge, the first attempt to use Granger causality methods in investigating the relationship between a monetary instrument and agricultural policies. Previous work (e.g., Chambers and Just 1981) had simply assumed that the relationship existed and then postulated an empirical model to measure the effect. The results of Barnett, Bessler, and Thompson suggest "a strong causal relationship between money supply and U.S. agricultural prices . . ." (p. 10). At the same time, they found "no evidence of agricultural prices causing money supply . . ." (p. 10). Epstein and Chambers have also found evidence of a causal relationship between the exchange rate and the level of exports of several agricultural commodities using Box-Jenkins and Granger causality techniques. Thus, while existing empirical studies may not be conclusive, they seem to point in the direction of an important link between monetary instruments and agricultural commodity trade.

At this point it seems appropriate to discuss the recent work of Van Duyne. Although not directly concerned with the effect of monetary instruments on agricultural commodity trade, Van Duyne's analysis specifically recognizes linkages between agricultural commodity markets and asset markets. Using a two-country, two-commodity (an agricultural and a manufacturing good), three-asset (domestic money, foreign currency, and commodity stocks) model, Van Duyne analyzes the effects of disruptions in the agricultural sector (such as bad harvest) on prices, exchange rates, and trade flows. Thus, his purpose is somewhat different than that of the present paper in that he is interested in the effect of agriculture on the general economy while we are mainly interested in the effect of certain monetary macroeconomic forces on agricultural commodity trade. However, the fact that he has specifically modelled linkages between the monetary and agricultural sectors is important and should provide a fruitful direction for further research.

Problems for Further Research

Although the level of the money supply is likely the single most important monetary instrument in the U.S. economy, there are numerous other monetary instruments (such as interest rates) which ultimately affect agricultural commodity trade. Furthermore, the somewhat spotty research in this area is in need of a widespread extension before it can be integrated into the main corpus of agricultural trade analysis.

Perhaps the first order of business in this area is the establishment of a satisfactory theoretical model of the interaction between monetary factors and agricultural commodity trade. The key to any analysis of this sort will be the manner in which linkages between the markets are specified. To see why, consider the following simple one-market, two-country model. Aggregate demand for agricultural commodities in the home country is represented by $D(p,M)$, where p is the price of the aggregate commodity and M is the disposable income. Aggregate supply is taken to be a function of the aggregate price and the interest rate (r), $S(p,r)$. If we use asterisks to differentiate the foreign country from the home country then trading equilibrium can be represented as

$$E(p,m,r) + E^*(p^*,M^*,r^*) = 0, \tag{1}$$

where $E(p,m,r) = D(p,m) - S(p,r)$. To complete the model, assume that the law of one price prevails, so that we can write $pe = p^*$ where e is the exchange rate between the domestic and the foreign currency. For the moment we presume that e is arbitrarily fixed by the governmental authorities.

We can use the model described by (1) to consider, say, the effect of a decision by the Federal Reserve to tighten credit and drive up interest rates—not unlike what we have witnessed over the past year or two. Differentiating partially with respect to r and expressing the result in elasticity form yields

$$\epsilon_r{}^p = - \frac{\epsilon_r{}^E}{\epsilon_p{}^E + \epsilon_{p^*}{}^{E^*}}, \tag{2}$$

where ϵ_j^i is the elasticity of i with respect to j. Under usual circumstances, the denominator of (2) is negative and ϵ_r^p, therefore, has the same sign as ϵ_r^E. Since ϵ_r^E represents the shift in excess demand of the home country associated with a change in the interest rate we can expect it to be positive. Thus, an increase in the interest rate yields an increase in price as denominated in the home country's currency. At the same time, the price as denominated in the foreign country's currency must also rise.

Turning to the direct effect on agricultural commodity trade, let us suppose from now on that the home country is the exporter of the agricultural commodity $[E(p,M,r) < 0]$. Using this assumption and the result in (2) establishes that in elasticity terms the comparative static effect on quantity traded can be written as

$$\frac{-\epsilon_r^E\,\epsilon_{p^*}^{E^*}}{\epsilon_p^E + \epsilon_{p^*}^{E^*}}. \tag{3}$$

By our earlier arguments we see that expression (3) is negative and that the amount of the commodity traded decreases as the interest rate rises.

Of course, these results are quite intuitive and can be shown using graphical techniques without resorting to the calculus. Consider, for example, figure 1, where I have represented the system graphically (assuming linearity). Panel (a) represents demand and supply conditions in the home country, while panel (c) represents demand and supply conditions in the foreign country. Panel (b) represents the excess supply and excess demand curves (assuming the home country is the exporter) derived from (a) and (c). Assuming that $e = 1$, we originally have trading equilibrium at price level P and quantity traded Q. Suppose that the interest rate rises; farmers are now likely able to afford a smaller debt burden and thus likely produce less at every price. The domestic supply curve shifts inward to, say, S'. The shift in S forces a shift from ES to ES' which in turn leads to the higher price of p' and lower amount traded Q'. We see immediately that the amount of the agricultural product consumed in the foreign country declines while foreign production rises. Domestic consumption falls while, in general, the effect on domestic supply is indeterminate.

Suppose, however, that the exchange rate is not fixed but instead, like the U.S. dollar, adjusts to forces in the international money market. One of the key determinants of the exchange rate in the monetary and asset market approach to exchange rate determination is the relative rate of interest between trading partners (Isard). In a world where monetary assets can move across international borders, one expects an increase in the interest rate to attract investment capital from abroad thus improving the country's payments position.

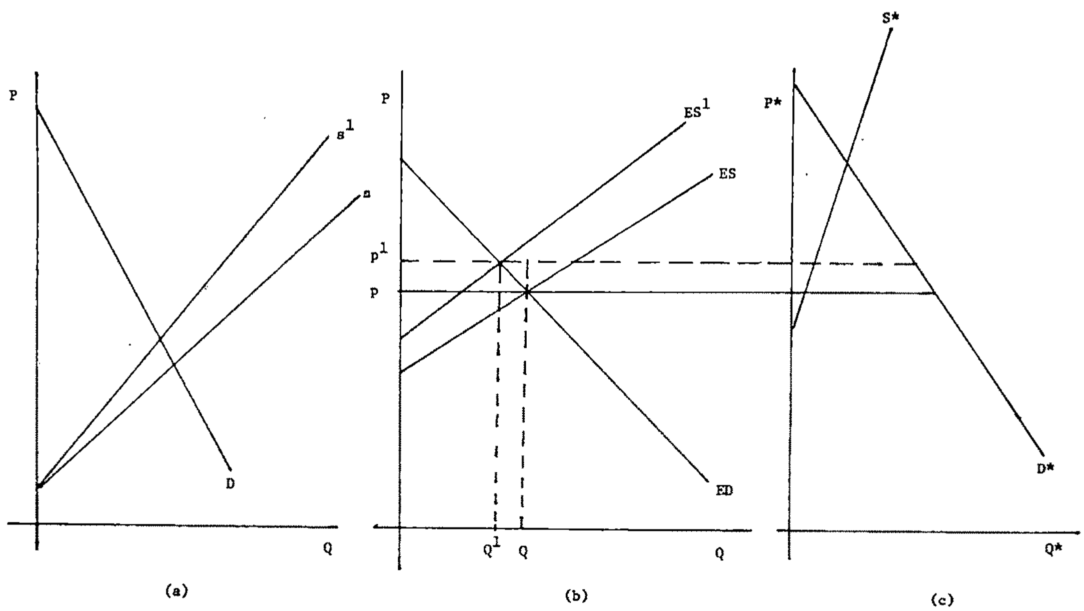

Figure 1. Effects of interest rate change on foreign trade

Therefore, in a flexible rate world it might be plausible to specify the exchange rate as a function of the relative interest rates, $e(r/r^*)$, where r^* is the interest rate in the foreign country. Denoting e' as the derivative of $e(r/r^*)$ we see that $e' > 0$.

Let us now perform the same comparative static experiment carried out above while recognizing that the exchange rate as well as agricultural production is now a function of the interest rate. Partial differentiation of (1) with respect to r and rearranging now obtains

$$(4) \quad \epsilon_r{}^p = - \frac{\epsilon_r{}^Z}{\epsilon_p{}^E + \epsilon_{p*}{}^{E*}} - \frac{\epsilon_r{}^e \epsilon_{p*}{}^E}{\epsilon_p{}^E + \epsilon_{p*}{}^{E*}}.$$

As we know from expression (2), the first term on the right-hand side of (4) is positive. However, since $e' > 0$ we can expect the second term on the right-hand side of (4) to be negative. Thus, the unambiguous result in (2) is replaced with an uncertain outcome. For the overall effect on prices to be positive it is necessary that $\epsilon_r{}^E + \epsilon_r{}^e \epsilon_{p*}{}^{E*} > 0$. We can expect there may be some instances when this inequality may not hold. Considering the effect on agricultural exports we obtain in elasticity form

$$(5) \qquad \frac{- \epsilon_{p*}{}^{E*}[\epsilon_r{}^S - \epsilon_r{}^e \epsilon_p{}^E]}{\epsilon_p{}^E - \epsilon_{p*}{}^{E*}},$$

which is negative under usual circumstances. Notice, however, that the overall decline in exports in (5) is larger than that found in (3). Thus, while quantity traded declines in both models, we perceive a tendency for the first model to underestimate the magnitude of the drop in exports associated with an increase in the interest rate. The reasons these results are obtained are quite simple and easily explained. As before, the initial effect, as far as the domestic agricultural sector is concerned, of a rise in the interest rate is to choke off domestic supply of the agricultural product which in turn tightens the supply situation in the international market. At the same time, however, the rise in the interest rate attracts investments to American shores thus forcing an appreciation of the now flexible exchange rate. While the tightening supply tends to drive the price of the agricultural commodity up, the appreciating exchange rate makes exports of the domestic country uniformly less attractive abroad. The decreased foreign demand for the commodity reinforces the downward export movement caused by the tightening of supply while it mitigates the original price rise caused by the shift in supply.

The important thing to note about (4) is not its ultimate sign, but that a relatively plausible generalization of even the simplest models recognizing the influence of monetary instruments on agricultural commodity trade makes it questionable what effects changes in monetary instruments have on agricultural trade patterns and agricultural prices. To appreciate the complexity of the problem at hand, one need only recall the extreme simplicity of the model involved and the fact that if it were to reflect adequately reality, the exchange rate would depend on agricultural trade flows as well as the level of the money supply and a galaxy of other variables that we have ignored.

If agricultural trade economists are to model accurately these phenomena, they must become much more acquainted with the operation of money markets. It is a curious phenomenon that most of the literature on agricultural trade (including the model above) takes a predominantly microeconomic, partial equilibrium approach. I do not mean to impugn the usefulness of partial equilibrium models. In many instances they are the most appropriate tool, but in others they have definite limitations which should be recognized. This is especially true when it comes to analyzing the impact of events that have their origin outside of the agricultural sector. Agricultural economists are not alone in their myopia. It is only relatively recently that writers on trade and asset markets have started to recognize the importance of agricultural phenomena for the overall economy in general (Van Duyne).

These comments suggest (or are meant to suggest) that an appropriate avenue of research in this area might include an extension of the research already started by Van Duyne. As I noted above, Van Duyne's analysis focuses on the effects of agriculture on the rest of the macroeconomy. It seems probable, however, that Van Duyne's model could be modified and extended to examine theoretically the impact of changes in asset markets on the agricultural economy.

The second major problem to be faced is the construction of empirical models, be they econometric or programming, that recognize the linkages between the agricultural trade sector and the money or financial part of our economy. A start, but only a start, has already been made in this direction by the studies of Chambers, Chambers and Just (1981), and Shei.

Researchers might follow the lead of empirical research in other areas of agricultural eco-

nomics that has been successful in introducing macroeconomic elements into agricultural models. The work of Penson, Penson and Hughes and Gardner (1976) serve as prominent examples. However, the first task that must be completed in this area is the identification of monetary variables that are likely to have an econometrically measurable effect on agricultural commodity trade. In the foregoing, we have already seen that several studies have been able to introduce the level of the money supply, the exchange rate, and the discount rate into agricultural trade models. However, there are likely to be many other essentially monetary factors or instruments which will have a dramatic impact on these markets. Before they can be included in structural models, they must be isolated. This area seems to be a particularly fertile ground for the use of causality tests of the type carried out by Barnett, Bessler, and Thompson.

Because it is always easier to suggest extensions of previous work than to pursue them, I have carried out some simple causality tests between several measures of agricultural commodity trade and several monetary instruments. These tests are rather quick and dirty and should be interpreted cautiously, but I feel that they provide some evidence on the relationship between monetary instruments and agricultural commodity trade. These tests rely on a somewhat arguable notion of causality developed and expounded in a series of articles by Granger and others (see especially Granger and Newbold) which suggests that causality requires a time delay. Thus, one time series is said to "cause" another if its past values somehow or other help to explain or lead current values of the other series. Rather than plunge into an extended discussion on the philosophical merits of this definition of causality, I refer you to a series of articles in the agricultural economics literature using this approach (Weaver, Bessler and Schrader).

My application follows that taken in the paper by Barnett, Bessler, and Thompson and boils down to simple regression techniques. If we have two time series $x(t)$ and $z(t)$ and the following regression equations,

$$(6) \quad x(t) = \sum_{i=1}^{m} a_i\, x(t-i) + e(t), \text{ and}$$

$$(7) \quad x(t) = \sum_{i=1}^{m} b_i\, x(t-i) + \sum_{i=1}^{p} c_i\, Z(t-i) + u(t),$$

where $e(t)$ and $u(t)$ are the stochastic components, $z(t)$ will be said to "cause" $x(t)$ if equation (7) provides a better description of the behavior of $x(t)$ than (6). As a practical matter the test of causality reduces to a test of the null hypothesis that $c_1 = c_2 = - \ldots = c_p = 0$ and can be based on the statistic

$$\frac{SSE_6 - SSE_7}{SSE_6} \, \frac{T - m - p}{p},$$

which is distributed as $F(p, T - m - p)$ where SSE_i is the sum of squared errors associated with equation i. To check for the existence of severe autocorrelation which might nullify the results of this test the Box-Pierce Q-statistic (see Granger and Newbold p. 93 or Bessler and Schrader) can be calculated and compared to tabulated chi-squared values.

Within this general framework, I carried out several separate investigations. I first tested the following four hypotheses: (*a*) the money supply does not "cause" agricultural exports; (*b*) the money supply does not "cause" agricultural imports; (*c*) the interest rate does not "cause" agricultural exports; and (*d*) the interest rate does not "cause" agricultural imports. As empirical measures of agricultural exports and imports I used value of agricultural exports and imports as reported in the *Survey of Current Business*. For the money supply I used currency in circulation, and for the interest rate I used the discount rate at the New York Federal Reserve. Data were monthly for the period 1973 through mid-1980 and $m = p = 12$. In both cases, there was no evidence of severe autocorrelation. The calculated F-statistics with (12, 56) degrees of freedom are, respectively: (*a*) 2.443, (*b*) 2.902, (*c*) 1.69, and (*d*) .9198. (*a*) and (*b*) are significant at the .05 level. Thus, there is some evidence for this time period of a causal relationship between money supply and agricultural exports and imports, with little evidence of a causal relationship between the interest rate and agricultural exports and imports.

From a somewhat more historical perspective, I next tested the null hypothesis that money supply did not "cause" the level of wheat exports for the period 1892–1952. Here the money supply is identified with the total currency in circulation in the United States. Data were annual and were obtained from *Historical Statistics of the United States*. The model used had $m = p = 5$. Again autocorrelation did not pose a serious problem and the calculated F-statistics with (5,50) degrees of freedom is 3.547 which is significant at the .1

but not at the .05 level. Thus there is some limited evidence of causality in this series as well.

One should be careful how these results are interpreted. A main reason for advising caution in this area is that there obviously exist several alternative measures of each of the aggregates under consideration. This is particularly true of the money supply variable. A glance at a recent issue of the *Survey of Current Business* reveals five separate definitions of the money supply ($M1 - A$, $M1 - B$, $M2$, $M3$, and L). Second, the approach used above leaves much to be desired, and a more attractive procedure for causal tests has recently been suggested by Ashley, Granger, and Schmalensee. However, the sort of test carried out above should remain attractive on a practical level in choosing variables to be included in larger-scale structural models.

The ultimate issue that one must face in any econometric or programming exercise is whether to build models specific to the problem at hand, as has been the case with the work of Chambers and Just (1981), or whether to aim at the construction of models that are sufficiently general to allow for a wide-ranging series of empirical examinations. The debate between big and small models is not new but is particularly relevant in this area because what is being suggested is the integration of two relatively disparate sectors of the economy in a single econometric or programming model. One must be particularly careful how this is accomplished since model specification ultimately determines the result of the modeling exercise. As a first step in this area, I would suggest the integration of reduced-form equations incorporating monetary instruments into fairly specific agricultural trade models. The literature on the specification of price transmission equations in econometric models of agricultural markets in developing countries that are isolated from the international market should be particularly helpful in this regard (e.g., Haessel and Vickery, Wong). Furthermore, because monetary instruments may often be classed as government controls, it seems that the work of Abbott on modeling governmental influences on international trade also would be particularly relevant.

I suggest the use of fairly specific models as a first step in this area because as a general principle it is necessary to know the enemy before he can be overcome. It seems better to first discover and solve the problems associated with smaller models and proceed from there to more complicated matters. One of the most valid criticisms of very large-scale general models is that, because of their very nature, they must ignore many details in their modeling effort. I feel that a more piecemeal approach would give modelers a better feel for just what can and cannot be ignored. On the other hand, large-scale models eventually will be indispensable to this area of research because it is only on a large scale that one can hope to capture all the market interactions and linkages which must be examined in such an area.

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Interrelationships between Spot and Futures Markets: Some Implications of Rational Expectations: Discussion

James D. Sullivan

Grain markets in recent years have been highly volatile making price forecasting increasingly difficult. Price variability is a complex problem not only for producers but for processors as well. Commodity purchasing decisions involving when to be long, short, or on the market are increasingly important. Understanding the relationship between the spot (cash) and futures markets is one of the most important elements in an effective and efficient commodity purchasing department. To those firms in agribusiness, futures markets provide tools for risk management and pricing. Thus, information or knowledge about these tools is valuable to business operations.

Dewbre states the purpose of his paper is twofold: first, proposing an econometric model recognizing rational expectations and, second, exploring the implications of such an approach on two issues. The implications are directed toward *(a)* given changes in economic information, what is the direction and magnitude of cash and futures price changes along with the accompanying direction of causality; *(b)* the forecasting performance of the futures markets.

Unfortunately, the final version and empirical results were received shortly before the meeting. In these brief comments, much of the discussion will center on the practical application of the proposed model. In bridging the gap between the theoretical and applied, questions will be raised about the empirical model, the data, and the conclusions.

The Model and Data

I commend Dewbre in his research effort. He has recognized and outlined the inconsistency of the two market theories, i.e., supply of storage and anticipatory prices in explaining and predicting cash and future price relationships. The agribusiness community deals with this inconsistency every day in the applied economics arena. The proposed model which incorporates the rational expectation hypothesis does, thereby, provide the avenue for exploring these shortcomings.

In general, any model attempting to explain empirical price movements for a commodity must be based on assumptions not only about the structural relationships that determine the price but also those that determine the production, consumption, and inventory level of the commodity. The assumptions one makes about the equations are critical in determining the appropriate model structure. The theoretical specification of the stock demand equation does not include the farm price support loan, but was discovered to be the most significant variable. I would suggest for consideration a variable measuring the competitive demand of commodities on storage capacity. This could be expected price ratios as proxies for one commodity's storage demand relative to others. There is a point of confusion about the graphical solution as presented. The confusion rests with the future period price expectation variable during the iterative process. It appears that lagged values of the price expectation variable are being used. Will this lead to an accumulation of estimation error? Data transformation on the stock demand equation in the empirical model could have been included in the theoretical specification.

Data problems abound in empirical research. The exclusion of the price support loan variable illustrates this point. Necessary information, but excluded, to test Dewbre's proposed model is the estimated historical time period. We do know the frequency of the

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period is monthly. It would be necessary for the proposed modeling approach to stand the test of time. The structure of the wheat market has changed. Wheat production and exports have grown considerably in recent years. A market participant's profile of rational expectations would be different in the 1960s than in the 1970s, particularly when one considers the importance of large export sales and changes in government policy reducing government stocks during the decade of the seventies. Other data questions: Why was the wheat market chosen for this investigative endeavor? Why the Kansas City market and not the Chicago market? How do we treat the various contract months?

The empirical results provide limited supportive evidence. Statistically, the results were satisfactory. However, no simulation or predictive results were presented. This is a necessary test for the proposed rational expectation approach. It was stated that over one-half of the turning points were picked up. I believe it is significant to know the circumstances surrounding those that were missed. An autocorrelation problem was admitted. The seriousness of this problem depends somewhat upon the pattern of estimation errors. Also, simulation results would have provided the necessary empirical evidence to support the graphical solution.

Dewbre's introduction of rational ecpectations in econometric modeling begins to close the gap left by the two well-known market theories. But, the paper does not provide sufficient evidence for me to accept the inferences drawn concerning the issues of direction, magnitude, and causality or that of the forecasting accuracy and performance of the futures markets. In both cases, he documents the conclusions drawn from prior research studies but fails to give enough supportive evidence, i.e., empirical results, to reach the conclusions drawn.

In closing, his paper does address the general theme of evolving relationships. I want to agree with inferences drawn with respect to direction, magnitude, and causality. However, I find that the analysis does not provide me with sufficient basis for complete acceptance. I do applaud Dewbre's effort. He has recognized and provided sufficient review of research to illustrate the shortcomings of the supply of storage and anticipatory price theories. The test of his approach lies with empirical and simulation results. I urge him to continue to pursue the matter and extend the analysis to other commodities.

Interrelationships between Monetary Instruments and Agricultural Commodity Trade: Discussion

Maury E. Bredahl

The evolving relationships of macroeconomic variables (which Chambers terms monetary instruments) necessitates two quite different types of analyses. The analysis of the evolving relationship of agricultural prices (and hence utilization, income, etc.) and macroeconomic variables in a post-harvest context (within marketing year) or across a few marketing years may be termed commodity analysis. The analysis of the evolving relationship of macroeconomic variables and the long-run equilibrium of the agricultural sector may be termed agricultural adjustment analysis.

Much of commodity analysis is logically directed toward the domestic and foreign demand sectors. The supply side of the livestock sector is also impacted by interest rate fluctuations in the short run. Much of this analysis utilizes a forecasting (versus projection) framework. This analysis identifies marketing strategies for farmers, procurement strategies for processing firms, and strategies for hedging in commodity and currency futures markets.

Agricultural adjustment analysis addresses the relationship of the long-run equilibrium in the agricultural sector (prices, comparative advantage, employment, for example) and macroeconomic variables. The results of this analysis might include a comparison of long-run adjustments to agricultural policies with flexible exchange rates versus fixed exchange rates, supply response to fluctuating (or high) interest rates, or changes in regional crop-livestock production in response to macroeconomic adjustments. This analysis requires a careful study of agricultural supply.

Consider the consumer demand for gasoline. In the short run, only the miles driven is a decision variable. In the long run, the replacement of the existing stock of cars (capital) with a more efficient fleet is the crucial factor. Forecasting gasoline consumption for the next six months (or even the next year) requires a much different analysis (model) than that required to project consumption for 1985 or 1990.

In my view, these two types of analysis of the evolving relationships in commodity markets are equally important and each deserves equal time. Chambers seems to address only the very important agricultural adjustment relationship. The remainder of this discussion presents my perspectives on (*a*) commodity analyses and macroeconomic variables, (*b*) agricultural adjustment, and (*c*) potential pitfalls of research on the interaction of macroeconomic variables and agricultural trade.

Commodity Analysis

A great deal may yet be learned from comparative static partial equilibrium trade models. Agricultural trade is characterized by numerous trade restrictions—many of a nontariff variety. It is characterized by state trading and large multinational grain firms. It is characterized by substitution among commodities (especially among feed grains, between feed grains and oilseeds, among vegetable oils, and between cotton and manmade fibers) in both the domestic and foreign markets.

Yet, much of the recent literature relies primarily on a free-trade, one-commodity model (Kost, Bredahl and Gallagher). A multicommodity model was presented by Chambers and Just but in a free-trade setting. Collins, Meyers, and Bredahl consider trade restrictions (via the price transmission elasticity) but in a single-commodity setting.

A logical progression of this type of analysis would seem to point to the development of theoretical multicommodity models that ex-

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plicitly consider trade restrictions. The impact of an exchange rate change may be much different in a restricted trade model than a free-trade model. For example, a devaluation of the dollar probably will reduce corn exports to the European Community (Bredahl et al.). On the other hand, oilseed exports would be expected to increase more than that suggested by a free-trade model. The internal corn price is fixed by the threshold price (and the variable levy) while soya prices would be reduced by a devaluation. Thus, soymeal would be substituted for corn in livestock rations.

I am less willing than Chambers to minimize the importance of the theoretical restrictions on structural and reduced-form elasticities derived from partial equilibrium models. The high correlation among economic time-series variables precludes, in many cases, the uncritical acceptance of econometric results. Theoretically derived restrictions play an important role in evaluating econometric results. For example, I have difficulty rationalizing a small, statistically nonsignificant, estimated coefficient on price with a large, statistically significant estimated coefficient on an exchange rate variable in export demand equations (Chambers and Just 1981).

Agricultural Adjustment

Although the long run is simply a series of short runs, quite different analysis (models) is (are) appropriate. The supply-side interaction with macroeconomic variables is most interesting. Important areas include capital formation, technical innovation and adoption, input costs, resource constraints, and labor migration. All of these variables are treated as exogenous in commodity analysis.

Chambers presents evidence of a causal relationship of monetary (macro) variables with agricultural exports and prices. This type of research is to be commended; the disconcerting gaps in our knowledge of these interactions should be closed. In addition to the caveats mentioned in interpreting Granger causality results, spurious correlation is assumed away; i.e., the apparent association between two variables occurs only because both variables are correlated with a third variable (Green and Albrecht).

A key question is the nature of the interaction between the agricultural sector and general economy. If the causality flows only from the general economy to the agriculture sector, agricultural models can be specified and estimated independently. If the interactions are simultaneous, the models must be estimated jointly. The causality evidence presented by Chambers seems to test only the unidirectional flow from the general economy to the agricultural sector. The test of simultaneous interaction of variables in the agricultural sector with those of the general economy variables is more interesting.

Given this emphasis, I am a bit puzzled by the direction of empirical research suggested by Chambers. The suggestion is "the integration of reduced-form equations which incorporate monetary instruments into fairly specific agricultural models." The testing of the interaction of the agricultural sector (particcularly agricultural exports) and macroeconomic variables (such as the interest and exchange rates) suggested by many agricultural economists (for example, Schuh, Tweeten) requires a much different emphasis. Many important questions—the impact of agricultural exports on the exchange rate, for example—cannot be answered by the approach suggested by Chambers.

Empirical Pitfalls

My empirical research has surfaced several factors that must be considered in research of the intraction of macroeconomic variables and the agricultural sector (trade). First, there is a clear distinction between commercial and noncommercial trade. The latter category includes PL480 and aid exports and trade by centrally planned economies. Commercial exports are clearly responsive to price (exchange rate) changes. Noncommercial exports would be expected to respond differently to price (exchange rate) changes or not at all.

Second, the impact of exchange and interest rates would be expected to vary among commodities. Trade restrictions are different for different commodities. An acceptable exchange rate measure specific to each of several commodities does not exist. The SDR-dollar ratio, which is heavily weighted by bilateral exchange rates of developed countries, is an unacceptable measure (except for soybeans and soymeal) because a large proportion of wheat and coarse grain exports are to developing countries. Price insulation policies also must be considered.

Third, cross-commodity effects are critically important. Substitution in both the

domestic and foreign demand sectors is well documented. Omission of these cross-effects leads to erroneous results and conclusions.

Fourth, estimated structural equations (and estimated reduced-form equations, for that matter) must be based on a sound theoretical model and recognize trade restrictions. I am continually mystified by the strong interaction hypothesized between wheat exports and the exchange rate. Consumer and producer prices in all developed countries and most developing countries are perfectly isolated from world market prices. Further, most income elasticities are small and, in some cases, negative. What is the mechanism, then, by which exchange rate variations impact significantly on U.S. wheat exports?

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The Differential Impacts of Inflation on Southern Plains Farms by Selected Farm Characteristics

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One important result of federal fiscal-monetary policy in recent years has been a general inflation so persistent that some observers fear that it may lead to a new structure of the national economy, perhaps with inflation as an inherent characteristic. Inflation is defined here as a continual increase in the average price level of goods and services. Serious questions arise concerning the impact of inflation on the farming industry. How will inflation affect ease of entry to the industry, and how will it affect the ability of farms of different characteristics to survive and expand? Do the traditional methods of farm financing continue to ensure survival of most types of farms at high levels of inflation? Would real growth of farm equity be enhanced by periodic indexing of the U.S. income tax schedules to the inflation rate?

The impact of inflation on the farming industry has been discussed by many authors from a general or aggregate perspective (Tweeten and Griffin, Ruttan, and Johnson, for example). The relationship between inflation and the farm sector's financial performance and structure, its financial markets and institutions, and farm level financial management, were recently surveyed, respectively, by Lins and Duncan; Klinefelter, Penson and Fraser; and by White and Musser.

Inflation impacts strongly on the main element involved in the expansion of the farm, namely land. Tweeten has shown that where inflation is fully anticipated, the cash cost of owning farm land is increased, while returns are partly deferred in the form of capital gains. Interest alone exceeds land earnings to produce negative cash flows; but, over time, the current returns increase to a point at which positive cash flow exists. In the purchase of land this phenomenon places the new entrant to farming at a competitive disadvantage relative to the established farmer who can use cash flow surplus from his existing holdings to offset the initial negative cash flow of a new purchase. The established farmer may also have a much greater advantage in the purchase of land if the mortgage interest rate that pertains to his existing holding was established before the present inflation was anticipated.

Inflation at high rates reduces the maximum size of farm that an entrant to farming may buy—directly because he can buy less land with a given equity, and indirectly because the diminished cash flow suffices only to support a smaller debt load. The case of a farm having zero cash flow in its first year was analyzed by Eginton, and is not considered in this study.

If land costs prove a barrier to entry in the farming industry, and if size and priority of establishment determine the potential for expansion, ease of entry to the industry and the national pattern of family farms will be seriously threatened. Entry, however, may still be feasible for limited resource beginners who have access to rental land and off-farm incomes.

Robison and Brake, applying capital budgeting techniques to long-term assets, have shown that the growth of the firm's equity will be reduced by inflation if lending limits are based on the income of the long-term assets.

Having indicated that a system of uniform loan repayments can contribute to the liquidity problem associated with inflation, Robison and Brake recommended use of a repayment system that more closely fitted the pattern of income under inflation.

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This paper focuses on microeconomic effects of inflation, reporting the results of simulating the effect of inflation on Southern Plains farms which differ by such features as enterprise mix, size, tenure, and growth strategy.

Model Development

The following analysis was conducted based on typical farms in Oklahoma, Kansas, and Nebraska as described in U.S. Department of Agriculture's (USDA) *Typical Farm Data Series* (Fawcett and Thornton). The series provided estimates of farm size, labor requirements and wages, value and composition of machinery, and livestock complements. Land prices provided by the series were updated to represent a 1979 purchase price.

Envisioned in the base scenario for each farm was a young married farmer with a wife and two infant children—the full family, operating as a sole proprietorship, and having before him an expected working life of thirty years, during which it is his objective to maximize the amount of land owned subject to a level of leverage that has acceptable risk. A modest level of living, $12,600 per year in 1979 dollars, is assumed. In cases where a farm does not provide the farmer full-time employment (2,000 hours/year), off-farm work is assumed to be available at $7.50 per hour, approximately the national average industrial wage for males in 1979. The farmer's family is assumed to provide 600 hours of farm labor per year, and the farmer provides the remainder up to a total of 2,600 hours for the entire family. The children leave the farm in the twentieth year, thereby reducing total labor to 2,100 hours per year. As farm size increases the farmer increases his on-farm hours at the expense of the off-farm hours. Hired labor is used when labor in excess of that supplied by the family is required on the farm.

It was assumed that the farmer at the start of the thirty-year period had farming experience in which he acquired requisite skills and creditworthiness, and, if not inherited, the capital needed to begin operations in year one of the simulation.

The simulation model, a modified version of that reported by Eginton, is used to estimate the growth path of net worth of farms synthesized from the input data of the *Typical Farm Data Series* of the USDA. The model first calculates income components based on equity, labor, management, and if appropriate, off-farm work. Equity income is based on a 4% real rate of return (Tweeten). Cash flow is calculated by deducting U.S. income taxes, social security payments, and debt retirement payments from income. The decision as to whether to expand, and by how much, is then made. Cash flow generated in a given year is spent 1 January of the following year if expansion is allowed.

It is assumed that the owner's first use of purchasing power for expansion is to replace rented land by owned land. When all rented land is replaced, further expansion requires purchase of auxiliary resources, livestock, and machinery. The model specifies that all cash on hand be spent before the line of credit is tapped.

Two growth strategies, A and B_1 were used. Strategy A, the cash-flow strategy, permits purchase of resources for expansion if, subject to a preselected maximum farm leverage level, a minimum of 40 acres of land and auxiliary resources can be purchased with available internal financing and a line of credit based on current cash flow, if positive. The magnitude of the line of credit is cash flow times the amortization factor for the resources being purchased. The amortization factor used was the uniform series of payments present value (USPV), given the appropriate interest rate and the term for which the money was lent. It was required that purchase be made to the value of the cash on hand and the total line of credit.

Growth strategy B_1 was based on the "mining" of equity as collateral for external financing of growth. A leverage ratio of 1 limited the line of credit, and there was an added requirement for resource purchase, namely that cash flow be positive in the current year.

Loans for the purchase of land were extended for thirty years using a 3% real rate of interest, and a system of equal loan repayments was used. A 4% real rate of interest was used for short-term borrowing associated with purchase of machinery, livestock, and the covering of cash flow deficits.

The model handles inflation through provision for inflating resource earnings and prices and through adjusting real rates of interest to nominal rates. The model provides for indexing taxes to inflation on an annual basis or at other regular nonannual intervals. Money values for output variables are all reported in real

1979 dollars. Unless it is otherwise indicated, income tax schedules were indexed annually for inflation.

The benchmark farms served as a focus of comparison for the alternative scenarios used in the study. Key characteristics were initial size of operation, initial tenure, and growth strategy employed.

The initial size of operation measures the acreage of land farmed in year one. Three sizes were chosen; the two smaller, one-third and two-thirds the size of the typical or family farm size, represent the more common entry level farm sizes; the largest represents the established farmer or rare wealthy entrant to farming.

In the context of this study the terms full owner, owner, and full renter signify initial full, half, and zero equity in land, respectively.

The attributes of the benchmark farms for Oklahoma, Kansas, and Nebraska are (*a*) the intermediate size, that is two-thirds of the typical size, (*b*) the owner status as defined above, and (*c*) the use of growth strategy A. The initial sizes of operation for the Oklahoma, Kansas, and Nebraska farms were 640, 425, and 425 acres, respectively, and their respective net worths were $400,000, $310,000, and $561,000. Initially, all farms had 100% equity in livestock and machinery.

Results

First the effects of inflation rates on the growth of equity in the three benchmark farms under various growth strategies are presented (tables 1 and 2) and discussed. Then the effects under inflation of initial farm size, initial land equity rate, and size of off-farm income are presented. Third, the impact of tenure under inflation is examined. Finally, results are presented showing how farm growth is affected by such factors as unanticipated inflation, failure to index the U.S. income tax schedules for inflation, and automatic quinquennial indexing of U.S. income tax schedules for inflation.

Equity Growth Rates under Inflation

The pattern of equity growth rates under inflation was similar for all farms across all growth strategies used (table 1). The pattern shows that growth rates at all nonzero levels of inflation up to 12% are above those for no inflation and that they first trend upward to a maximum between 3% and 7% inflation and then trend slowly downward. Most net worth growth rates peaked at 6% or 7% inflation.

Data from table 2 provide insights into the behavior of the system underlying the growth rates pattern in table 1. The pattern of growth across inflation rates reflects the influence of factors such as (*a*) the growth strategy used, (*b*) the nonlinearity of the U.S. income tax schedules, and (*c*) the use of uniform loan repayments schedules.

With higher inflation, the greater interest rates reduce income initially, causing negative cash flows, thereby restraining growth in period one, the first fifteen years. Subsequent

Table 1. Results of Thirty-Year Simulation Showing the Impact of Inflation on the Growth Rate of Net Worth of Benchmark Farms in the Southern Great Plains Using Two Growth Strategies

	Compound Annual Rates of Growth					
Farm[a]	Oklahoma		Kansas		Nebraska	
Growth Strategy[b]	A	B_1	A	B_1	A	B_1
Inflation Rate (%)						
0	3.75	4.57	4.63	5.85	3.42	4.12
1	4.02	5.27	4.85	6.40	3.68	4.73
3	4.54	6.15	5.39	7.21	4.27	5.87
5	4.71	6.51	5.38	7.56	4.42	6.37
6	4.72	6.53	5.28	7.64	4.43	6.07
7[c]	4.72	6.30	5.15	7.50	4.44	5.89
12	4.68	5.64	4.91	6.43	4.26	5.34

[a] Oklahoma: a typical Oklahoma commercial cotton, wheat, and beef farm, initial size 640 acres; Kansas: a typical Kansas commercial wheat sorghum, beef farm, initial size 425 acres; Nebraska: a typical Nebraska irrigated corn farm, initial size 425 acres.

[b] See text for details of growth strategies. Growth strategy A sets borrowing limits on the basis of cash flow, and growth strategy B_1 uses equity as the basis of borrowing.

[c] Data not shown here indicates that the maximum growth rate for both Oklahoma and Nebraska under growth strategy A occurred at 7% inflation.

Table 2. Results of Thirty-Year Simulation with the Oklahoma Benchmark Farm

		Inflation 0%			Inflation 6%			Inflation 12%		
	Units	Year 1	Year 30	Change[b]	Year 1	Year 30	Change[b]	Year 1	Year 30	Change[b]
Growth strategy A[a]										
Acres owned	Acres	640	1,240	600	640	2,080	1,440	640	1,680	1,040
Acres added (period 1)				600[c]			400[c]			160[c]
Net worth[d]	$1,000	400	1,207	807	400	1,598	1,198	400	1,483	1,083
Net worth growth rate	%		4.38[c]	3.75		4.69[c]	4.72		4.40[c]	4.46
Cash flow	$1,000	9.8	−29.4	−3.5[b]	0.4	13.8	7.2[b]	−16.9	16.9	5.5[b]
Negative cash flow (no.), mean	$1,000		(15)	−4.9[b]		(0)	0.0[b]		(8)	−3.2[b]
Personal income	$1,000	35.4	61.7	50.4[b]	16.1	48.4	30.1[b]	−3.5	34.2	23.8[b]
Income taxes (U.S.)	$1,000	6.0	17.2	11.2[b]	0.6	4.1	2.5[b]	0.0	0.8	1.8[b]
Growth strategy B_1[a]										
Acres owned	Acres	640	2,000	1,360	640	4,040	3,400	640	2,760	2,120
Acres added (period 1)[c]				600[c]			800[c]			400[c]
Net worth[d]	$1,000	400	1,530	1,130	400	2,672	2,272	400	2,073	1,673
Net worth growth rate	%		4.69[c]	4.57		6.20[c]	6.53		5.21[c]	5.64
Cash flow	$1,000	9.8	−11.1	3.8[b]	0.4	−7.9	−0.0[b]	−16.9	−42.5	−15.0[b]
Negative cash flow (no.), mean	$1,000		(7)	−1.2[b]		(14)	−1.8[b]		(24)	−16.6[b]
Personal income	$1,000	35.4	86.5	57.4[b]	16.1	44.6	27.6[b]	−3.5	−6.4	−9.3[b]
Income taxes (U.S.)	$1,000	6.0	21.9	11.6[b]	0.6	0.0	0.0[b]	0.0	0.0	0.2[b]

[a] See footnotes, table 1, for details of the Oklahoma farm and the growth strategies. Strategy B is similar to strategy B_1, except that expansion is not restrained by the positive cash flow requirement of strategy B_1. Dollar values are comparable, being 1979 dollars.
[b] Number identified by "b" are thirty-year averages.
[c] Data pertain to period 1, the first 15 years.
[d] Net worth for years 1 and 30 are, respectively, as of 1 January and 31 December. The average net worth is that for end of year.

recovery leads to stronger growth in the second period. For example, under strategy A, at 12% inflation, period one growth rate of net worth is 4.40%; but for the overall period it is 4.46%. Similar results are obtained for strategy B_1, but the magnitude of growth rates reflects the generosity of the line of credit associated with the strategy.

In the absence of inflation, growth rates of net worth were lowest. With strategy A, all of the acreage expansion occurred in the first period (table 2). Data not shown revealed that all of the purchases of 600 acres of land were made by year eight, and thereafter no purchases occurred. The reason is that cash flow, which with low interest rates was large in the first year, thereafter declined continually so that negative cash flows averaging $4,900 occurred throughout the second fifteen-year period. The system of uniform loan repayments and high taxes contributed to this outcome. In the absence of purchases for expansion, interest payments declined annually at an increasing rate, and principal payments increased by an identical amount. Taxable income increased as interest payments declined, and taxes increased disproportionately because of increasing marginal rates. Taxes and principal payment increases far exceeded the increase in income annually and the result was an ever-declining cash flow.

Great increases in farm size were achieved under strategies B_1 at 6% and 12% inflation. The results show that by operating under fairly restrictive leverage ratios growth can be considerable if lenders are willing to provide short-term financing for cash-flow deficits.

The Impact of Initial Size of Operation on Growth of Equity, Given Inflation

The results for the three sizes of farm under two levels of inflation (scenarios 1 to 6), table 3, show that the large farm grew faster than the medium-sized farm, (4.87% vs. 4.72% at 6% inflation, for example). However, the growth rate of the small farm was greatest of the three at 12% inflation and greater than that of the medium-sized farm at 6% inflation. The relative success of the small farm in growth rate (but not absolute growth) is attributed to the strong influence of off-farm income in the first period of fifteen years, where the growth rate was much higher than for the overall period. The greater growth of the large farm is attributed to the greater initial net worth and size which made more income available for growth. Scenarios 7 and 8, compared to 5 and 6, show that with the same initial size of operation at both levels of inflation, the farm with the smaller net worth makes smaller absolute increases in net worth. However, the rates of growth do not always correlate with initial size of net worth. Scenarios 9 and 10 compared to scenarios 6 through 8 show that a high off-farm wage ($15.00 vs. $7.50) can go a long way toward boosting the expansion of farm size. Growth rates were increased by about one percentage point. It must be noted that off-farm income here, through its contribution to growth in early years, causes itself to be phased out. An owner with a high off-farm wage could opt to hire farm labor to service his farm growth and continue to work off-farm with dramatic effect on his farm growth rate.

In synthesizing the small farm from the typical farm, no downward adjustment of rates of return was made to reflect possible losses in operational efficiency. If such adjustments were made, it is likely that increases in net worth would have been modest.

The Impact of Tenure on Growth of Equity

The full renter grew at a faster rate than the full owner, but the full owner added substantially greater equity to his farm in thirty years. Having only 640 acres to farm, the renter benefitted from off-farm income to the extent of $5,700 per year on an average (table 4). An increase in size of operation would help the initial renter, but he would lose some of the benefits of off-farm income; therefore the high rate of growth could not be maintained. Note that year 1 results are the same irrespective of the inflation level in both main tenure situations—because assets are held at full equity in year one by both full owner and the renter. Data for the owner is included for contrast. The very modest increase in net worth (in thousands of dollars) for initial renter, 266, is dwarfed by that for the full owner, 2365. In year thirty, the renter still had smaller equity in real terms than had the owner in year one. Land ownership in farming is seen to be the primary criterion for success. By reducing initial land ownership through smaller mortgage that can be serviced with cash flow, higher inflation rates give a comparative advantage in farm growth to high-equity or established owners at the expense of the low equity and entry level farmer.

Table 3. Results for the Oklahoma Farm Showing the Growth Impact of Initial Size of Operation, Initial Land Equity Percentage, and Off-Farm Wage Level, at Two Inflation Rates (Growth Strategy A)

Scenario Number[a]	Unit	1	2	3	4	5	6	7	8	9	10
Farm characteristics											
Initial acreage owned		320	320	960	960	640	640	640	640	640	640
Initial land equity (%)		50	50	50	50	50	50	25	25	25	25
Initial net worth ($1,000)		200	200	600	600	400	400	233	233	233	233
Off-farm wage ($/hr.)		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	15.0	15.0
Inflation rate (%)		6	12	6	12	6	12	6	12	6	12
Item											
Increase in acreage owned	Ac.	680	560	2,400	1,640	1,440	1,040	400	240	800	640
New worth											
Net worth (year 30)	$1,000	809	806	2,509	2,255	1,598	1,483	913	874	1,191	1,163
Growth rate years 1–15	%	5.20	5.15	4.57	4.13	4.69	4.40	5.57	5.17	6.80	6.63
Growth rate years 1–30	%	4.77	4.76	4.87	4.51	4.72	4.46	4.66	4.51	5.59	5.51
Average net farm income	$1,000	17.8	13.4	40.1	27.1	30.0	21.6	19.2	4.3	22.3	9.7
Average off-farm income	$1,000	7.0	8.2	0.1	0.3	2.0	3.4	4.8	5.2	6.6	8.8
Average income tax (U.S.)	$1,000	2.2	1.6	3.0	1.5	2.5	1.8	2.7	1.9	2.9	2.2
Average cash flow	$1,000	4.2	4.9	11.1	4.6	7.2	5.5	−6.5	−31.4	2.8	−10.9

Note: See footnotes, table 1, for details of the Oklahoma benchmark farm, and of growth strategy A. Dollar values are comparable, being 1979 dollars.
[a] It is assumed that initial machinery and livestock complements are fully owned; therefore, for a given size of operation, net worth difference reflect the different percentages of equity in land.

Table 4. Results of Thirty-Year Simulations with Tenure and Ownership Variations of the Oklahoma Benchmark Farm, Using Growth Strategy A at Two Inflation Rates

Initial Tenure:[a]		Full Owner[c]			Full Renter[c]			Owner (Land Equity 50%)			
Inflation Rate:			6%	12%		6%	12%		6%		12%
	Units	Yr. 1	Change[b]	Change[b]	Yr. 1	Change[b]	Change[b]	Yr 1	Change[b]	Yr. 1	Change[b]
Total assets Controlled	$1,000	735	4,896	3,521	735	0	0	735	1,666	735	1,210
Acreage operated	Acres	640	4,240	3,040	640	0	0	640	1,440	640	1,040
Acreage owned	Acres	640	4,240	3,040	0	320	320	640	1,440	640	1,040
Land equity	% Acres	100	(2,174)	(1,836)	0	(259)	257	50	(1,101)	50	(990)
Total assets	$1,000	735	4,896	3,521	71	339	332	735	1,666	735	1,210
Net worth	$1,000	735	2,727	2,365	71	275	266	400	1,198	400	1,082
Net worth growth rate	Percent		5.30	4.92		5.71	5.62		4.72		4.46
Net farm income	$1,000	40.2	49.5	36.5[b]	13.4	14.6	14.0[b]	10.1	30.0	−10.0	21.6[b]
Off-farm income	$1,000	6.9	0.3	0.6[b]	6.9	5.7	5.7[b]	6.9	2.0	6.9	3.4[b]
Personal income	$1,000	45.4	47.7	36.0[b]	19.2	18.7	18.4[b]	16.1	30.1	−3.5	23.8[b]
Income tax (U.S.)	$1,000	10.0	1.8	1.0[b]	1.3	1.6	1.4[b]	0.6	2.5	0.0	1.8[b]
Saving & investment	$1,000	22.8	33.3	22.5[b]	5.3	4.5	4.4[b]	2.8	15.0	−16.1	9.5[b]
Cash flow	$1,000	22.8	18.0	19.6[b]	5.3	2.8	4.1[b]	0.4	7.2	−16.9	5.5[b]

[a] See footnotes, table 1, for details of the Oklahoma farm and the Growth Strategy A.
[b] Numbers identified by "b" are 30-year averages.
[c] For full owner and full renter year 1 data at 6% inflation are the same as those at 12% inflation because there is no debt in either tenure situation in the first year.

Inflation, Taxation and Interest Rates

Expectations by the electorate that high inflation will persist could result in Congress being pressured to index taxes to inflation. The absence of tax indexing produced the lowest growth rate of the Oklahoma benchmark farm, 4.19% (table 5). Indexing taxes every five years was nearly as beneficial to growth as indexing annually, and annual average income tax paid increased by only $200. Both instances of tax indexing increased growth rates by about one-half a percentage point above the nonindexing result.

Failure to anticipate inflation by the lender who financed the original land purchase, resulting in a 3% nominal instead of a 9% nominal interest rate, would prove beneficial to the owner of the Oklahoma farm. The growth rate increased by 1.24 percentage points, based on a loan on 320 acres at 1979 prices, fully leveraged.

Finally, the no-tax scenario is included, not because it is realistic or likely, but to show the magnitude of the impact of the tax burden at 6% inflation. It accounts for 0.4 percentage points difference from the indexed taxes result. That small change reflects the low annual average tax burden experienced at 6% inflation by a farm which has substantial deductions to keep taxable income low.

Summary

The growth rates of net worth under inflation first trended upward and then trended downward slightly. The peak growth rates were reached between 3% and 7% inflation; most, however, peaked at 6% or 7% inflation. The proportional impact on net worth growth rate from 6% to 12% inflation was uniform across farms of widely differing characteristics. At highest inflation rates, however, the growth rate of equity tended to decline. Moreover, at inflation rates above 6% cash flow deficits were common. Although leverage ratios were low, the magnitude and frequency of cash flow deficits were such that lenders who have not yet fully accepted the permanence of capital gains equity would probably be reluctant to offer refinancing.

If a family farm structure is consistent with rapid expansion to an economic size unit in early years and restrained growth in later years, results of this study indicate that low inflation rates contribute to such a structure. Furthermore, low inflation rates allow an entry level operator with a given equity, management, and labor reserves to purchase a large farming unit. Low inflation rates also allowed farmers with a given equity to get off to a faster start, using cash flow surpluses to purchase more land. With time, uniform annual payments on mortgages having an increasing component of principal payment, raised taxes and reduced disposable income for expansion. The situation could be different if a given equity would have been used initially to finance purchase of as large a farm as possible subject to equity and cash flow restraints.

Initial equity was a major factor determining the absolute growth in farm size, with full owners growing far more than renters beginning with the same acreage. The implication is that if society wishes to restrain growth of farms, estate taxes can play a major role by reducing equity passed to heirs who enter farming. Such a policy would need to be accompanied by policies such as higher property tax rates for nonoperator owners to discourage investment in farmland by nonfarmers.

These results depend heavily on the assumptions which included availability of off-

Table 5. Inflation, Taxes, and Interest Rates Results for the Oklahoma Benchmark Farm, Using Strategy A

	Growth Rate	Net Worth Year 30	Acres Owned Year 30	Income Taxes Mean	Cash Flow Mean
	(%)	($1,000)	(Acres)	($1,000)	($1,000)
Taxes not indexed	4.19	1,372	1,600	6.5	4.8
Taxes indexed, 5-year	4.70	1,586	2,040	2.7	6.8
Taxes, indexed annually	4.72	1,598	2,080	2.5	7.2
Low interest rate[a]	5.96	2,273	3,120	3.0	11.6
No taxes	5.12	1,792	2,440	0.0	8.6

Note: See footnotes, table 1, for details of the Oklahoma benchwork farm and of growth strategy A. An inflation rate of 65% was used in the low interest rate case (inflation not anticipated).

[a] An interest rate of 3% nominal was used (even though 6% inflation existed) on the mortgage for the original purchase. The mortgage represented the value of 320 acres at the 1979 price.

farm employment, deterministic growth not subject to shocks which could cause illiquidity, full anticipation of inflation, a constant low real level of consumption, and uniform debt payment schedules. The model, which currently provides fairly crude approximations of long-term results using a parametric approach, does so at a very low cost. It could, however, be made much more sensitive and realistic by including elements to make explicit adjustments with respect to many of the assumptions listed above and with respect to a number of assumptions implicit in the model. Future studies will include a more detailed modeling of the mechanisms through which inflation is incorporated in agriculture, a more conventional consumption function, stochastic income elements, and loan repayment schedules other than the equal loan repayment schedule currently used.

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Changing Agricultural Prices and Their Impact on Food Prices under Inflation

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We know that mankind has lived with, suffered the consequences, or reaped the benefits of inflation since records have been kept. Despite the centuries of experience and hours of study and debate, we still are far from understanding how to deal with persistent inflation and, in many cases, cannot agree among ourselves as to when or where its influences are beneficial or burdensome.

From our particular orientation and training, it is difficult for us to address the issues of inflation in anything but a microeconomic perspective. Yet at the microeconomic level, there is no inflation, just price change. So before we begin, let us look a little closer at inflation. There is far less agreement, we find, on a definition of inflation than there is on the consequences of price increases. We sketch out this process by way of introducing the empirical work we report later in this paper. This process reveals that microeconomic price increases in one sector, through their initial effect on consumer demand and their direct and indirect effects on costs of intermediate materials in other industries, can lead to inflation in the macroeconomic sense. Because this process is so fundamental to the way we measure the effects of inflation, it is worth looking at it in somewhat more detail.

To use a common economists' device, assume that oil prices rise worldwide, with domestic prices rising in lockstep. The immediate effect will be on consumption. With energy prices higher, substitution will occur—less energy (gasoline, home heating oil, etc.) will be consumed relative to other commodities. Simultaneously, higher energy costs as factors of production or intermediate materials will permeate the industrial structure of the economy. With higher relative energy prices, firms will substitute capital and labor for energy until, at the margin, relative prices are equated to relative marginal products. This will raise costs to all users of energy in rough proportion to their energy use, with consequent increases in product prices. Increases in product prices will, likewise, stimulate increases in negotiated wages as workers attempt to retain their prior relative standard of living. Higher wages and higher product prices will cause other changes in consumption. Clearly, this process, to the extent that it persists, is what we call inflation.[1]

There are several aspects of this process that we can highlight: (*a*) one consequence of price changes is a change in consumption patterns; (*b*) changes in costs will alter production arrangements in other industries, not just that industry immediately affected by price changes;[2] and (*c*) "second-round" effects will wash through the entire economy, including the industry initially affected. All of these are microeconomic effects of inflation. But the task of measuring them requires a macroeconomic perspective.

Even the concept of inflation is macroeconomic. Consider the definition of Prentice and Schertz (p. 1): "Inflation, a rise in the general price level, represents a decline in the real purchasing power of money." The terms "general price level" and "purchasing power of money" are macroeconomic, not microeconomic in nature. Johnson's (p. 104) definition, while very similar—"a sustained

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[1] We chose this particular commodity to illustrate that inflation may well be a consequence of normal economic activity, in contrast to the undertone in much of what is written that suggests that inflation is somehow imposed on the system. Continuous depletion of a nonrenewable resource can certainly lead to persistent price increases, and to increases in the general price level if the resource has limited substitutes. This analysis is further predicated on the reasonable empirical assumption that the Federal Reserve System, whether using interest rates or monetary aggregates as intermediate targets, cannot effectively prevent such price changes from affecting the general price level.

[2] The effects of uncertainty on the decision making of the firm is another consequence of inflation, quite apart from the adjustments required by changing relative prices.

rise in prices"—has the added advantage of simplicity. But Johnson recognizes that "one encounters problems of some difficulty as soon as one tries to apply it in practice." The three major difficulties are (*a*) some price increases are not inflationary; (*b*) the choice of which prices or indexes are to be used; and (*c*) most measures of price do not adequately reflect quality changes. Another definition, attributable to Pigou (p. 14), finds inflation to exist when "money-income is expanding relative to the output of work by productive agents for which it is the payment." This attention to income flows or factor returns is the complement to price changes in commodity markets; it stresses the general equilibrium, or microeconomic, aspects of inflation.

This paper will address some inflationary effects—we concentrate on measurement rather than attribution. Since we are dealing with microeconomic measurement, by which we mean measurement of specific elements such as the number of beef cows on farms, we will avoid much of the argument about cause. Instead, we focus on price changes and the consequences of these changes.

This, then, is what interests us here: the adjustments that are made necessary by price increases and how these adjustments influence food and agriculture. We gauge these adjustments by simulating the microeconomic activity in the agricultural sector with the Merrill-Lynch Agricultural Model. This simulation provides prices, quantities, and markups for the major outputs of the agricultural sector. These are then used to examine the macroeconomic consequences of changes in the agricultural sector using the Battelle FORSYS (Forecasting System) macroeconomic model. The results of these simulations are reported in the fourth section of this paper. Sections II and III provide descriptions of the agricultural and macroeconomic models, respectively.

The Merrill-Lynch Agricultural Model

The Merrill-Lynch agricultural model is a quarterly microeconomic model of major agricultural commodities. The crop portion of the model is a disequilibrium submodel, allowing for partial price adjustment when current and desired stocks are not in equilibrium. The livestock submodel is an equilibrium model that uses the U.S. Department of Agriculture supply-utilization accounting framework.

The livestock submodel has markets for beef cattle, calves, hogs, broilers, turkeys, eggs, and milk. Price determination occurs at the wholesale market, with marketing and processing costs added to obtain the retail price. Farm price is determined from the wholesale market price by taking into account transportation and other costs.

The crop submodel has markets for food grains (three wheat commodities and rice), feed grains (corn, oats, barley, and sorghum grain), oil crops (soybeans, peanuts), and cotton. Production is determined from yields and acreages, with utilization demands and desired stock positions determining the current market price at the wholesale level. Equilibrium price at the farm level and cost of production then determine acreage planted with crops competing for alternative uses of land.

Farm income is based on production and farm level prices for cash receipts and input costs and cost of production for expenses. The CPI for food and beverages is derived from producer level prices for agricultural commodities and markups that result from additional processing and retailing.

The major exogenous inputs to the agricultural model are disposable per capita income, interest rates, population, the CPI for all items less food and beverages, and major wholesale prices that constitute costs of agricultural production—fertilizer, fuels and natural gas prices, and machinery costs. Wage rates and transportation costs are used to determine the marketing and processing costs that get added to determine retail prices. The major program variables that enter are loan rates, farm-held reserves, target prices, and other support program variables. Set-asides and acreage diversions are also included in determination of acreage planted.

Some of these exogenous variables are determined in satellite models run prior to a solution for the agricultural model. The two major agricultural satellite models are the fertilizer model and the farm machinery model.

Battelle's FORSYS Macroeconomic Model

Battelle's FORSYS (Forecasting System) macroeconomic model is a 112-sector, annual, dynamic, input-output model of the U.S. economy. Final demand consists of consumption detail by fifty-nine categories, investment detailed by eighty categories of producers

durable equipment, and twenty-seven construction categories, government expenditures, and net exports. Gross output is determined from these final demands and the input-output structure of the economy. Prices and wages are determined by sector within the model and are used to determine net incomes to business and consumers. Relative prices and incomes are determinants of consumption and investment decisions. Interest rates are determined endogenously in a monetary sector that relies on major monetary flows among agents of the economy to determine effective prices. We look briefly at each of these sectors, then describe how information from the agricultural sector model is introduced into the FORSYS model. We touch but lightly on all sectors except consumption, which plays a prominent role in our results.

The solution process for the FORSYS model begins with an initial estimate of prices and income used to compute consumer demand by product. Prices for the fifty-nine categories of consumption are obtained by conversion of the supply prices by input-output sector. For example, a dollar spent on personal consumption category titled "semidurable household furnishing" may be distributed to a number of FORSYS manufacturing industries, as well as transportation and trade margins. Thus the price for semidurable household furnishing is constructed as a fixed-weight aggregation of the market prices for these same sectors. With prices by consumer good and total expenditures, a simultaneous system of demand functions is employed to predict expenditures by fifty-nine categories of consumption. These consumption estimates are derived from a two-step decision process, with consumers first allocating their budget among nine broad categories: food, fuel, clothing and footwear, household operations, household durables, private transportation, health services, and other services and nondurables. After expenditures on each of these aggregate groups is determined, the model then allocates expenditures among the subcategories within each group. This system of equations is based on the indirect transcendental logarithmic utility function, which allows for both substitution and complementarity among consumption commodities, both within and between the broad categories.

FORSYS next determines the other elements of final demand and output: exports, imports, government expenditures, inventory change, fixed investment, and gross output. With current estimates of output and capital stock (derived from investment and past capital stock), a "desired" level of employment for the current year is obtained. This and previous employment determine current employment. Unit labor costs, based on wage rates and labor requirements, are then one of the major explanatory variables in the determination of prices.

Domestic prices in the FORSYS model follow the price "dual" formulation of input-output theory. Material costs are passed through on a dollar-for-dollar basis, while factor returns, making up value added, are treated separately. Supply price is then determined as a weighted average of prices of these domestically produced commodities and imported commodities.

The FORSYS model then ties this information together by estimating various income components of aggregate income, calculating the required national income and product accounts, estimating the domestic saving rate and hence determining consumer expenditures, which feed back into the demand system. We need further explain only how agricultural forecasts from the agricultural sector model feed into FORSYS.

FORSYS contains seven consumption sectors and five input-output sectors that tie in directly to the agricultural sector model. The consumption categories, meat and dairy products, poultry and eggs, fruit and vegetables, fats and oils, bread and cereal products, purchased meals and beverages, and tobacco products, tie in directly with the categories in the agricultural sector model that relate to consumer prices. Quantity and price for the five input-output sectors can be built up from the commodity detail of the agricultural sector model. Of these five sectors—dairy and poultry products, meat animals and livestock, cotton, food and feed grains, and other agricultural products—all but the last are determined endogenously. Two other input-output categories, meat and dairy processing and other food processing, are available to satisfy final demand for food consumption.

We modify our macroeconomic forecasts by first altering the domestic agricultural price for commodities. This modification then influences the PCE deflators with consequent adjustment in consumption. Shifts in final demand then change the composition of output, and ultimately alter income and relative

prices. The model is in equilibrium when the adjustments are complete.

Simulations with the Models

Our empirical results consist of four impact analyses of the agricultural model with one impact analysis of the macroeconomic model. For our baseline we simulate both the agricultural and macroeconomic models beginning in 1977. Our results are then reported as deviations from this baseline. The three extreme agricultural simulations examine (*a*) the effect of eliminating the farm-held reserve; (*b*) the impact of a 10% increase in the CPI for all commodities less food and beverages; and (*c*) the effect of raising income 1% for each of five years. A less extreme simulation increases both prices and income. The price changes that result from the second simulation of the agricultural model are then used to simulate the macroeconomic model, measuring the consequences of the agricultural sector changes on the macroeconomy.

Agricultural Model Simulations

Our first simulation is designed to gauge the impact of support programs on agricultural commodity prices. We proceed from the belief that inflation is transmitted to agriculture via dependence on inputs that originate off-farm. We then examine how these changes are retransmitted to the general economy via changes in raw material prices and through taxes drawn to support agricultural commodities.

The agricultural support mechanism is, in fact, one of the ways in which general inflation is institutionalized into the agricultural economy. It also serves to spread some of the risk inherent in agriculture across a wider base. Since the primary "damage" done by inflation at the microlevel is to increase risk, the support mechanism serves to reduce some of the detrimental impact of inflation. We cannot, however, argue that the net effect has contributed to the efficient use of resources: this will occur only if the support rates have been established from accurately anticipated changes in relative prices—a most unlikely event. The cost of these supports is inefficiently organized resources if they do not reflect market relative prices.

Consistent increases in corn production costs have been translated into the corn loan rate, and the loan rate, in turn, has provided a lower limit to prices. The question, then, is what influence has this had on food and agriculture?

The first agricultural model simulation suggests that, so far as the American consumer is concerned, the absence of farm-held reserves would have made very little difference in the near term. Food prices would have been only slightly lower for the first year. Prices received by farmers for crops would have been lower initially, but livestock prices would have increased. Table 1 shows the changes in cash receipts, prices received, and the CPI for all food.

The data in table 1 show about a $1 billion net negative impact on cash receipts for the first two years, but a net increase of $20 billion for the second two years. These results, at least partially, reflect the short crops of 1980 and the transfer of supplies from the first two years to the latter two years, via the grain reserve. We do not propose that these results reflect the impact of more or less inflation; rather, they indicate that attempts to spread the risk (to achieve stable farm incomes or food supplies) must result in both costs and benefits. In the special case shown here, the maintenance of farm-held reserves causes producers of crops to benefit through stable short-term income, but livestock producers to lose. Higher feed costs would discourage increased meat production and, although food prices decline initially, reduced meat production will mean higher prices later.

Table 1. Impact of Eliminating Farm-Held Reserve—Cash Receipts and Prices 1978 to 1981

	Year			
	2	3	4	5
	---- (Change) ----			
Prices received[a] (%)				
Crops	−3.3	−1.1	4.2	4.5
Livestock	.8	6.3	8.2	6.1
Cash receipts ($ bill.)				
Crops	−1.1	3.4	2.3	5.9
Livestock	.3	3.3	6.4	6.0
CPI—all food[a] (%)	0	.4	1.2	1.1
Beef cattle on farms[a] (mill.)	.1	.2	1.0	1.9
Breeding sows[a] (mill.)	.1	.5	1.0	1.2

[a] Fourth quarter.

This simulation illustrates two important points. First, market intervention in the form of support programs has a differential impact on agricultural producers, with dynamic consequences that are difficult to anticipate. Second, support programs institutionalize a higher cost structure.

It is through this higher cost structure that evidence is gained to support the proposition that inflation is good for (or at least not harmful to) agriculture. We would take issue with this argument unless it is made conditional on higher costs institutionalized by support programs. Gardner, for example, concluded that a 1% change in the CPI would result in a $950 million increase in real net farm income. Tweeten and Griffin report that prices paid by farmers will respond (long-term) one-to-one with general inflation and found no significant relationship between general inflation and prices received.

Our second simulation provides some evidence regarding inflation and agriculture. We find that an increase in the overall CPI does have an influence, but primarily through reduced real consumer incomes. A 10% increase in the nonfood component of the CPI gives us an initial 5% reduction in crop prices, 10% reduction in livestock prices, and about a 9% drop in total cash receipts (table 2). These results occur since, with nominal income held constant, the increase in the CPI reduces income enough to disturb significantly food consumption patterns. We emphasize that this simulation represents an extreme case, but we use these extremes to bracket our results.

So, our third simulation looks at another extreme. When real income is elevated by 1% for five years, we obtain results much like those of Gardner. At the end of five years, cash receipts are $1.8 billion higher, with a mid-period average of slightly over $900 million. Because production expenses have been held constant, this also represents the change in net income. Our final simulation tries to find a set of assumptions intermediate between these extremes; we balance increases in both the nonfood CPI and income increases with less dramatic results. Cash receipts are marginally lower and net income is also lower because of the production cost pass-through observed by Tweeten.

We conclude, then, that inflation is not harmful to agriculture only when it is validated by government support programs. Without this validation, our findings suggest that a 1% increase in inflation will reduce farm prices and income by approximately 2%.

Table 2. Percentage Change in Prices Received and Cash Receipts Resulting from a 10% Increase in Nonfood Components of the CPI

	Years				
	1	2	3	4	5
Price received					
Crops	−5.3	−8.8	−8.9	−7.0	−4.9
Livestock	−10.0	−8.0	−4.0	−1.0	−1.0
Cash receipts					
Crops	−7.5	−11.0	−12.0	−10.0	−7.5
Livestock	−11.0	−10.0	−6.0	−2.0	−2.0

Simulations with the Macroeconomic Model

To validate that the consequent effects of the initial price changes represented by the second agricultural simulation would have no devastating effects on the initial macroeconomic simulation, we resimulated the macroeconomic model for a 10% reduction in livestock prices and a 7% reduction in crop prices. The simulation affirmed our major concern about the effects of agricultural price changes on real income, that the effects were negligible. So the agricultural sector simulations are uneffected in any major way by processing these changes through the macroeconomic model.

Of more interest to this paper is the impact of these price changes to the consumption pattern of consumers and the supply prices of the nonagriculture sectors of the economy. We highlight these results in table 3.

Conclusion

Persistent price changes outside of agriculture bring about changes in the cost of production. All other things being equal, farm income will decline. Thus, if we measure the well-being of the farm sector in terms of real farm income, abstract from the effects of inflation on land values and ignore the uncertainty effects of inflation on production, then we conclude that inflation has a substantial negative effect on the income position of agriculture. But all

Table 3. Macroeconomic Changes from Agricultural Price Reductions, First-Year Effects

	Level	Percent Change
GNP (bill. $1972)	+.7	0.05
PCE (mill. $1972)	+452	0.05
National income (bill. $)	−5.6	−0.46
Disposable income (bill. $)	−7.0	−0.55
Food consumption ($ mill.)		
Meat and dairy	733	1.4
Poultry and eggs	500	3.4
Fruits and vegetables	215	0.8
Fats and oils	266	5.9
Bread and cereal	33	0.2
Purchased meals	−364	−0.6
Agricultural investment (mill. $1972)	$ 79.6	0.6
Gross agricultural output (mill. $1972)	$983.4	0.8
Implicit deflators (1972 = 100)		
Gross national product	−0.7	−0.5
Personal consumption expenditures	−0.8	−0.6
Livestock products	−6.9	−4.7
Fruits and vegetables	−4.0	−2.6
Fats and oils	−3.9	−2.6
Bread and cereals	−2.9	−2.0
Purchased meals	−1.9	−1.3

Note: Livestock and product prices reduced 10%; other food products reduced 7%.

other things are rarely the same. The observation that inflation has little or no harmful effect on the farm economy we attribute to two compounding influences: first, government support programs have institutionalized higher costs, thus mediating the effects of inflation; second, coincident inflation and rising real income make it difficult to identify the separate effects of these two, allowing the erroneous conclusion that inflation does no harm to agriculture.

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Microeconomic Impacts of Inflation on the Food and Agriculture Sector: Discussion

Vernon R. Eidman

The O'Carroll paper addresses several inflationary impacts on farm firms. I will start by critiquing the issues addressed and then turn to a discussion of additional work that might be beneficial.

The first set of results suggests that the real growth rate of equity reaches a maximum as inflation reaches 3% to 7% and then declines for higher rates of inflation. The rates of growth are somewhat greater when a higher leverage ratio is used, but the peak occurs in the same inflation rate range. The author indicates the reduction in growth at higher inflation rates occurs because the greater interest rates reduce income in the earlier years, causing negative cash flows during the first fifteen years. However, the rather surprising result (of lower real rates of growth with inflation rates above 3% to 7%) appears to be caused in large part by the zero real rate of growth assumed for land values. Including a real growth rate of 3% to 4% for land values (which recent studies such as Melichar's would tend to support) would result both in larger equity gains and increased borrowing possibilities. Through the compounding effect, the addition of real rates of growth in land values would increase the cash flow each period, with the amount of the increase being greater for higher rates of inflation. Thus it cannot be argued that this effect would be uniform for all rates of inflation. The sensitivity of the model to this factor should be considered before concluding that real rates of equity growth decline as inflation rates move above 3% to 7%.

The second section considers the effect of alternative farm sizes under two levels of inflation. The relatively favorable showing of the small farm is largely dependent on the availability of off-farm work and the manner in which the annual net cash flow is calculated (which I comment on below). Further, the author notes that a high off-farm wage could have a dramatic effect on the farmer's growth rate—not a surprising result.

The results for alternative tenure situations suggest that the full-renter grew at a faster rate, but that the full-owner added considerably more equity to his farm in thirty years. Inclusion of a positive real rate of growth in real estate values (as noted above) would enable the full-owner both to grow at a faster rate and to add to equity more rapidly than the O'Carroll results indicate. This would make the full-tenant less competitive relative to the full-owner.

Perhaps the most interesting result is the estimated impact of indexing taxes to inflation every year, every five years, and no indexing. The author indicates indexing taxes every five years rather than every year yields approximately the same rate of growth in equity—a rate approximately 0.5% greater than with no indexing over the thirty years.

The summary indicates that similar results were obtained on farms of widely differing characteristics. However, all of the farms have a similar crop-livestock mix and all have a substantial amount of net worth at the start of year one. The method of calculating the annual net cash flow, the manner of including off-farm employment and the assumption on family living further restrict the range of situations analyzed.

The Oklahoma, Kansas, and Nebraska farms considered are primarily crop farms with relatively minor livestock operations. Neither intensive livestock farms nor crop farms in other regions were considered. The lowest equity situation considered was a renter on a 640-acre Oklahoma farm with an initial net worth of $71,000, who owned the machinery and livestock debt-free. Each of the other farms had a starting net worth of at least $200 000. Farms with initial low net

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worth and poor debt-equity ratios were not considered.

The method of calculating the net cash flow further reduces the distinction between alternative farming situations. Net cash flows were calculated as 4% of the owned land value, plus a fixed return per hour of operator and family labor, plus the operator-management return (calculated as a fixed percentage of cash receipts), plus a fixed return per dollar for investments in machinery, plus a fixed wage per hour for off-farm work, minus a fixed family living expense, minus mortgage payments, minus federal income tax, minus the social security tax. The use of a fixed rate of return to land, labor, capital, and management resources minimizes the differences in level and pattern of net cash flows that exist between farms of different types and sizes.

The assumptions concerning the availability of off-farm employment and family living requirements are the same for all farms, another reason for similar growth rates across alternative farms. In each case, off-farm employment was considered to be available at $7.50 per hour for operator labor not required by the farming operation, regardless of the season of availability. Furthermore, consumption for the family of four was assumed to be a constant $12,600 in 1979 dollars. Both the low and constant real consumption level as the family's age and financial situation changes appears unrealistic. For these reasons it is difficult to agree either that a wide range of firms was considered or that the results obtained are indicative of the firms analyzed.

Perhaps a somewhat different approach to estimate the differential impacts of inflation on alternative sizes and types of farms would be more fruitful. A given rate of inflation as commonly measured can arise in a variety of ways, with each of these ways resulting in a somewhat different set of farm level input and product prices. This makes it difficult to select one combination of input and product price changes to consider in a firm level model for a given rate of inflation. However, Kite and Roop's paper suggests a way out of this dilemma.

Alternative combinations of inflationary forces could be selected and macroeconomic models of the economy used to trace the impact of the forces on the price of inputs farmers purchase and the demand for agricultural products. The equilibrium product prices at the farm level could be calculated with a model of the major crop and livestock sectors. The resulting input and product prices could be used in firm-level simulation model to test the impact of inflation on farm firm growth.

The farm simulator would need to be more detailed than the O'Carroll model. To serve as a useful experimental device, the firm simulator must include a sufficient level of detail to trace the impact of price changes and the resulting operator's decisions on the finanability of returns to productive assets. The ple, the inclusion of alternative production systems (reflecting alternative labor-capital combinations that can be used to produce a product) for each alternative product is important for two reasons. The optimal system may change as the firm's equity position improves, and the optimal production methods and product combination may change as inflation affects relative price ratios. Including the stochastic nature of production may be important in areas of high yield variability because of its effect both on net cash flows and the leverage ratios that can be sustained. One of the characteristics commonly associated with inflationary periods is increased uncertainty of input and product prices, indicating such variability should be considered in the model to assess the effect of inflation on rates and variability of returns of productive assets. The major income tax provisions available to farmers provide an important means of reducing variation in after-tax net cash flow and should be included.

It might be argued that interacting the several levels of simulation models will be too time consuming and expensive for consideration. However, Kite and Roop have described models that might be used to estimate the impact of certain inflationary forces on input and product prices at the farm level. Detailed simulation models developed for more conventional firm growth studies are available for some typical farms to assess the impact at the firm level. The availability of models suggests interacting the aggregate and firm-level models may be quite feasible.

Basing the farm-level analyses on specific sets of price changes would estimate differential impacts of inflation for alternative resource situations including land qualities, tenure, size, equity, etc., as desired. This approach is a potentially richer source of data on the firm level impacts than using models which ignore shifts in production methods and product mix, production and price uncertainty, and income tax effects. The approach would estimate the rate of return to land, labor, capital,

and management by size and type of farm rather than assuming they are constant in real terms for all farm types over time as the O'Carroll model does.

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Microeconomic Impacts of Inflation on the Food and Agriculture Sector: Discussion

Michael L. Walden

The topic of inflation and its impacts has received a great amount of attention by the public and the media for obvious reasons. Unfortunately, much of the discussion provided in these forums has been misdirected with respect to the meaning, causes, and consequences of inflation. The economics profession is looked to for guidance and analysis that will aid both private and public decision makers in deciphering the meaning and implications of inflation.

The paper by Kite and Roop represents an attempt to apply the analytical tools of the profession to measuring the impacts of inflation on a particular economic sector, here the food and agriculture sector. Unfortunately the work is flawed in several major aspects. Most significant among the paper's problems is the authors' failure to conceptualize and define inflation properly. Kite and Roop claim that inflation has its origins in microeconomic price increases, i.e., "microeconomic price increases in one sector, through their initial effect on consumer demand and their direct and indirect effects on costs of intermediate materials in other industries, can lead to inflation in the macroeconomic sense." As an example, they cite the standard description, often presented by the popular press, of how oil price increases permeate the economy, causing complementary increases in non-oil factor inputs, wages, and product prices—in short, general inflation.

Clearly, this conceptualization and causal explanation of inflation is contrary to the most elementary principles of macroeconomics. The refutation of the oil price (or for that matter, any other factor input) argument as a cause of inflation hardly needs repeating. In brief, increases in the price of any factor input (e.g., oil) will be followed by price increases in all products only if the monetary authorities accommodate the original price increase with increases in the money supply; in the absence of such an accommodation, higher expenditures on oil products can be realized only by lower expenditures, and demand, on non-oil products. The result is a rise in oil sector prices balanced by a fall in non-oil sector prices and no change in the average price index (Levi, pp. 59–60).

The fundamental problem with the Kite-Roop conceptualization of inflation is the failure to distinguish between "inflation" and "price changes." Elementary economic theory teaches us that any individual product price change can be decomposed into two parts: one part caused by nominal, or money, changes, and a second part caused by real (demand and supply) changes in the individual product's market. Only the former influence is properly termed an inflationary impact; i.e., inflation is properly defined as a rise in the general price level resulting from macroeconomic changes. If general price level changes, or changes in its stimuli (i.e., money supply) are properly measured, then its impact should be on a one-to-one basis with individual product price changes. Recent research supports this hypothesis for aggregate agricultural prices (Grennes and Lapp) and for retail food prices (Belongia and King). Product price changes different from changes in the general price level are caused by real supply-demand shifts in the product's market. Admittedly, some of these real effects may arise from an interaction between general price level changes and institutional factors in the product's market (the interaction of the investment tax benefits of homeownership and land and "bracket creep" produced by inflation are the best examples). Any investigation into the impacts of inflation on individual product prices should attempt to sort out these sources of change. Interesting research questions concern the lag structure of the nominal inflationary impact (see Belongia and King)

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and the effects of institutional interactions with inflation.

The failure to distinguish between nominal and real aspects of price changes plagues the Kite-Roop analysis throughout. In essence, since Kite and Roop do not distinguish between nominal and real impacts, price changes which they label as "inflationary" are really an aggregate of nominal and real effects. Changes in agricultural support prices, changes in real income, and changes in agricultural input prices do not represent changes in inflation (properly defined). The closest that Kite and Roop come to modeling the impacts of inflation is their simulation involving an increase in the overall CPI index. However, in simulating this effect they hold nominal income constant, hence not recognizing that inflation is a neutral nominal increase in all prices, including the price of labor. Therefore, Kite and Roop never do investigate the topic of their research; that is, they never do investigate the microeconomic impacts of inflation.

It is difficult to judge adequately the two simulation models without seeing a copy of the equations, parameter estimates, and the analysis on which the parameter estimates are based. Therefore, several questions and concerns come to mind with respect to the models. How is inflation generated in the models? When an individual real price rises, do the models assume that the real price change will be accommodated and spread throughout the economy via nominal inflation impacts? What is the structure of the monetary subcomponent and how does it interact with other parts of the model? Do the models adequately compensate for labor productivity and technological changes? For example, Belongia found a causal relationship between retail price increases and increases in nominal wages in excess of the growth rate of labor productivity in only one commodity group. How do the models handle the interaction of inflation with institutional arrangements which may produce nonneutral impacts from inflation? For example, do the models simulate the changing investment patterns of households during inflation? What theoretical assumptions are implicit in Kite and Roop's use of "mark-up" rules for pricing between wholesale and retail levels, and are these assumptions justifiable? Last, how have the models been validated, and what were the results?

In light of the above criticisms and questions, it is not possible to make informed comments regarding the results of the simulations. Instead, let me conclude by presenting an outline of a research strategy for investigating the microeconomic impacts of inflation. First, any such research must be properly grounded in economic theory; this involves a proper conceptualization of the differences between "price changes" at the microlevel and "inflation." Second, such research should include an understanding of the macroeconomic causal forces affecting inflation, which necessitates an incorporation of money supply generation and growth. The latter is particularly important because the money supply is a policy variable which can be manipulated by policy makers to influence the rate of inflation. Last, such research should attempt to separate and measure the impacts of nominal and real factor changes on microprices. The aforementioned research by Belongia and King and Grennes and Lapp already represents fruitful work following this approach.

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Technical and Decision Aids for Local Decision Making
(Judith Collins, EES, U.S. Department of Agriculture, Presiding)

Management Information Systems for Local Government

Arlo Biere and John Sjo

For some time private firms have used computer-based comprehensive management information systems. Local governments also have used computers to process data, but local governments lack comprehensive management information systems—for several reasons: (*a*) they have not had or have not allocated resources to develop such systems; (*b*) the nature of local governments make such development difficult; (*c*) interstate differences in local governments make it difficult to design systems that can be used nationally; (*d*) local governments lack incentives to acquire such a system; and (*e*) private vendors have not developed and marketed such systems as they have for private businesses.

Here we discuss local governments' need for assistance to develop management information systems, constraints that keep them from adopting such systems, and how adoption might affect local governments' capacity. We describe briefly the management information system we developed for and instituted in county governments in Kansas and conclude by discussing the role of economists in system design.

Local Governments Need Assistance

System development and implementation is complex and time consuming. Such a system consists of (*a*) a management organization description that specifies flows and uses of management information, (*b*) software to handle the data described above, and (*c*) a computer to process the data. The first of the three is most critical. How well the management system is organized and understood will determine the limits of the software performance and the computer's usefulness in handling expected tasks. Except for large metropolitan governments, a local government lacks the resources—financial and technical—to develop its own management information system. Attempts to modify systems developed for private firms have not been successful because management characteristics of local government differ too much from those of a business in at least five ways.

Local governments have no single objective measure of performance as do private firms. In business, profit is a measure of performance and of capacity because the entrepreneur's objective is to produce profits. Also, that profit motive provides harmony of purpose among all managers within a business. Governments are formed to provide services to citizens. For them, profit is not a reasonable measure of performance and no other measure is a good substitute. It is hard to measure performance other than by voter satisfaction, which tends to be *ex post*. Lacking an objective performance measure, various participants in local government—elected officials, bureaucrats, and citizens—each may have a different concept of a local government's purpose. That lack of a single performance measure and of a harmony-of-purpose control factor requires a more complex management information system as no single indicator contains all crucial information.

Local government decision making is a political process where the decision makers are both internal and external. So the management information system must provide information to the public (external) as well as to elected officials, appointed officials, and other employees (internal). The information needed by the public has not been determined. Lack of such information to the public may stem

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from current information systems not being capable of providing it in a way it can be used or from government officials not wanting to make full disclosure, which would reduce their discretionary power.

The political process of decision making produces a sense of discontinuity because leaders are elected and the election of an opposition candidate may result in certain programs being discontinued. That potential for discontinuity may cause employees to concentrate their efforts on short-run strategies. An information system can provide incentives to develop longer-run management strategies.

Most governmental revenues come through coercion—taxation—or through monopoly power. Except for utilities and other services sold to the consumer, public services provide benefits so widespread that few individuals would be willing to purchase the service individually. The services are financed by taxing the citizens so the acquisition of resources does not depend directly on consumer satisfaction with the service. Accountants describe this condition by saying that expenditures for such services do not generate revenue as does a product produced for sale by a private firm.

Because revenues to finance such public services do not come from the sale of the service, state legislatures grant local governments authority to levy taxes for specified purposes. Fund accounting is used to segregate and account for such money as it is received and disbursed. Other public services, like utilities, may generate their revenue, but a local government that produces and sells those services usually has a monopoly. So, whether the service is financed by taxes or by selling the service, there is no competitive market pressure for efficient production. For a government to have an efficiency objective, it must be an explicit objective because economic efficiency is not implicit in the governmental process.

Because of the way resources are obtained and because of the importance of the political process, the annual budget is the central tool guiding government expenditures. It has more force than a budget in private business where it is just a planning tool. When a local government adopts its annual budget, it establishes the spending authority (appropriations) for the next year. Expenditures must be within the appropriations. Exceeding the original budget is difficult. Legislative action by the local government is required to change appropriations, and state administrative approval may also be required. With a budget serving as such a strong control, comparisons of actual expenditures with the budget allocations guide expenditure decisions.

The strong annual budget influence restricts governmental administrators in making long- or intermediate-run decisions. Long-term planning is further inhibited because governmental officials do so little of the actual budget development. In Kansas we find that county budgets are prepared by an outside auditor consulting with the board of commissioners and other officials. The auditor is hired to prepare the budget because, with current information systems, budgeting is so difficult and complex. So, while the process of budget preparation offers the best opportunity to establish long-run plans, much budget preparation is turned over to an outside auditor or financial advisor.

From the viewpoint of an administrator, the annual budget process produces temporary property rights (appropriations). An administrator runs two risks when making expenditures from appropriations: exhausting the full appropriation before the end of the budget year, and not expending the full appropriation by the end of the budget year. Those two risks can dramatically influence an agency's efficiency.

Statutory and regulatory provisions are prominent in local government affairs. State statutes and administrative rulings govern the conduct of business in local governments. Two such examples are state standards regarding accounting and state laws and regulations governing the property taxation process. A management information system must be designed to meet such requirements.

Statement 1 of the National Council on Governmental Accounting, issued in 1979, says the basic financial statements of a governmental unit should be prepared to conform with generally accepted accounting principles. When financial statements so prepared do not demonstrate statutory and regulatory compliance, the unit shall prepare additional schedules to demonstrate such compliance. That clarified an earlier position taken by the Municipal Finance Officers Association that accounting systems should first satisfy statutory and regulatory requirements. Although the clarification has simplified accounting

problems for local governments, most local governments still use a single-entry, cash-accounting system. A challenge facing many states is to get local governments to adopt generally accepted double-entry and accrual accounting practices.

A management information system designed to meet the needs of local governments can contribute to the more effective and efficient operations of local governments. But local governments differ so much from private firms that it is not feasible for a local government to adapt a management information system for a private firm to its needs. Because most local governments do not have the resources to develop their own management information systems, land grant universities can do that, just as they have helped individual farmers to improve management on their farms.

Constraints to Adoption

We found local governments planning to adopt a new management information system must deal with the high initial cost of a new system, delayed benefits, stresses the new system has on the administrative structure and on affected personnel, and possible quick obsolescence of the new system.

Adoption of a new system means investing in equipment, software, supplies, and personal training. Initially, extra effort must be expended to put data into the new system and to make the gradual transition from the old to the new system. That may mean additional labor costs for the first year, when benefits received from the system are smallest. The benefits of the new system will not be realized until personnel can use it proficiently and know how to use the information produced. Another benefit after the first year is that some data, such as voter registration and real estate assessment data, need to be entered only once and updated thereafter.

The management information system must be consistent with the unit's organizational and operational procedures. When not, the inconsistencies must be reconciled. For some inconsistencies, unsatisfactory procedures should be discarded, e.g., abandoning single-entry cash accounting. Because a high degree of standardization of procedures is used in computer processing, some procedures acceptable with manual processing may not be acceptable with computer processing. Adoption of a new system provides the opportunity to improve governmental operations. Stresses on the administrative structure may not be welcomed and may create conflicts between offices if the new system changes the relationship between offices. Education for the changes and consultation with concerned individuals can help to avoid new conflicts between offices, to speed acceptance of the system, and to avoid rejection of the new system before benefits from it are realized.

Implementation of a rational system places new strains and risks on decision makers. Argyris has concluded that a rational management information system can create conditions where executives experience (*a*) reduced freedom of action, (*b*) a sense of psychological failure because of the management system's constraints, and (*c*) a decreased feeling of importance as they see (*d*) emphasis on leadership based on competence instead of formal power so familiar to managers. Those implementing a management information system must cope with the emotional stress the system produces—for themselves and their employees.

A local government considering a new management information system may already have had unpleasant experiences in adopting new methods of data processing. During the 1970s many local governments purchased computers expecting to solve their data problems only to be disappointed with the results. For some, disappointment turned to exasperation when they learned that the purchased equipment was depreciating 30% or more per year. Such an experience has caused some officials to be highly skeptical of new technology.

Role of Management Information Systems in Capacity Building

McDowell identified development of management information systems as one strategy to increase the capacity of a local government. Biere and Sjo discussed how information systems impact capacity by drawing an analogy to the general welfare economics model. Here we discuss the impact of improved management information on capacity by studying the definitions of capacity and their implications. Honadle reviewed several definitions of capacity and concluded that no consensus definition appears in the offing. Instead, she offers a framework for thinking about capacity build-

ing. Capacity, she says, is the ability of a local government to anticipate and influence change, to make intelligent decisions about policy, to develop programs to implement policy, to attract and absorb resources, to manage resources, and to evaluate current activities to guide future actions.

To expand on Honadle's framework, we suggest considering the differences between the concept of the firm and the Robinson Crusoe example. When considering the capacity of a private firm, one usually refers to its ability to produce a certain volume of a good or a service or of a bundle of goods or services. That is really an intermediate measure of capacity. From the viewpoint of the entrepreneur, a firm's capacity would be defined relative to his objective so it might be measured by profit or a related measure.

Within Honadle's framework there is a similar ultimate objective for local governments. Her definition of capacity refers not to an intermediate measure comparable to the volume of goods and services produced by a private firm, but an ultimate objective that justifies the local government's existence, which is not the same as it is for a firm. In the case of the private firm, production is separated from consumption and price serves as the informational link between consumption and production. Profit can be determined readily as the firm, by using market prices and input-output rates, can compute the value of the output and the value of the resources consumed. That profit provides a measure of capacity and an indication of the firm's ability to survive.

Local government is more similar to the classical Robinson Crusoe example of a man who makes production and consumption decisions in combination. As a producer of public services, the local government must make production decisions. As an institution for public decision making, the local government determines what public services shall be provided—at what level and to whom—and how the services are to be financed. The latter function distinguishes a local government from a firm. But production and consumption decisions can be difficult to separate. With does not separate a decision on road improvements from providing for the improvement through the road department.

We find Honadle's definition and most other definitions of capacity to be based on a concept of a local government analogous to a private firm. Such a concept fails to recognize the more crucial role of making public choices regarding the level and mix of public services and regulations and how they will be financed and enforced. Those issues have impacts that are embodied in those five characteristics of government discussed previously and that greatly add to the complexity of a management information system and make it more difficult to determine its adequacy.

Although the Robinson Crusoe example is more appropriate than the private firm example, the Robinson Crusoe example ignores the high human interaction in operating local governments. Involved are citizens, elected officials, political party officials, special-interest group members, and employees of the local government. Those employed in government recognize that the government does not have a single measure of performance and that the decision-making process is complex. Those conditions give each employee much latitude to interpret his duties and to justify his performance. Furthermore, management controls and information systems for government tend to be less developed than for a private firm. Those conditions have remarkable parallels with the five basic elements of Leibenstein's micro-micro theory of production: (*a*) Individuals in the organization are selectively rational. (*b*) Individuals in the organization are the basic decision units. (*c*) Each individual in the organization has discretion over his effort. (*d*) Individuals in organizations may be inert to organizational pressure. (*e*) The organization is subject to organizational entropy or the natural tendency toward disorganization.

Those five conditions make it desirable to consider the individual as the fundamental decision unit, not the local government. Then, the outcome of local government activities reflects the aggregate of individual actions. A good management information system should help the organizational structure to aggregate

human interaction present. The role of the management information system is to provide information to assist managerial control of the production activity and to provide relevant information regarding public issues to all who participate in the decision-making process. But the information needs may differ in each case. To inform citizens so they can make intelligent collective decisions requires different information from management information necessary to guide government's internal operations.

The lack of management information systems for local governments seriously detracts from this governmental capacity. It is our premise that developing and adopting management information systems will contribute to local government's capacity by providing information so citizens can make more informed decisions and by providing a control mechanism that assures that the local government operates to produce selected public services efficiently and effectively.

Kansas Local Government Information System

In 1975 the Board of Commissioners of Ellis County, Kansas, invited the Kansas Agricultural Experiment Station to develop a new management information system for that county government. The board previously had purchased two small computers to handle the county's data processing. County officials were frustrated by the limitations of the computers, by increasing reporting requirements of the state, and by finding that data processing on the new computers was not fully compatible with the county's needs. County officials had thought the computers acquired would solve their data handling and management information problems. Instead, they created more problems!

The first product of our work was a report on the organization and operation of the Ellis County government, including a study of statutes pertaining to the management of a Kansas county. Ellis County's operation and organization were tested against those statutes. When the county's operation or organization conflicted with state statutes, we met with county officers to reconcile the differences.

The second product of our work was a restructured management information system, consisting of procedural manuals and computer software to perform the needed data processing. The manuals are organized by major components of the management information system. Each volume of the manual reviews key statutes affecting that part of the management information system, lists the objectives, and describes both how to use the component and the steps to using the system, including how to prepare originating instruments, to key data, and to obtain reports.

The county keys data at the courthouse and transmits the data for processing by telephone on a remote job entry terminal to a central computer at Kansas State University. Most print jobs are transmitted by telephone back to the courthouse. Large print jobs, such as printing tax rolls, tax statements, and tax receivable files, can be done at the central computer. Remote processing was chosen because it offered greater capabilities and because the county was relieved of the cost and responsibility of operating a computer in a courthouse. That choice originally gave the county no local computing capabilities. New remote entry terminals can be used both to transmit and receive data and to process small jobs locally. We are scheduled to add a cash register to the system this fall to capture data on cash received in the treasurer's office.

The system has six subsystems (see Sjo and Biere): a name file, taxation, accounting, payroll, physical assets accounting, and voter registration. The financial portions of the system are fully integrated, designed to leave an audit trail, and to provide data security. The accounting subsystems are designed to conform to generally accepted accounting principles (GAAP) as given in *Governmental Accounting, Auditing, and Financial Reporting.* Also, the accounting subsystem is designed to permit a user to obtain cost accounting by office and by job category within an office.

The name file, a supporting subsystem to the taxation system, is a computer-maintained list of the persons, firms, and organizations with which the county conducts transactions.

The taxation subsystem is used to keep assessment records, to levy taxes, to record tax collections, to abstract taxes levied and taxes collected by taxing districts, to process delinquent tax accounts, to prepare tax warrants and tax sales, and to record collections on tax warrants and tax sales.

The accounting subsystem is a double-entry fund accounting system. Revenue and estimated revenue transactions may be recorded also by office receiving the revenue. All ex-

penditures, encumbrances, and appropriations are recorded both by fund and by office. Each office is treated as a cost center. It is then possible to obtain the full expenditures made by any office, and those expenditures can be identified by the fund the expenditures were made from. An office also may designate a job code to identify in that cost center the activity that incurred the expenditure.

The physical assets accounting subsystem provides an inventory of each physical asset item. It can calculate depreciation on depreciable fixed assets. Such depreciation is used for cost analysis only.

The payroll is processed through a payroll agency fund. Labor service expenditures are recorded in the accounting subsystem as transactions between the payroll agency fund and the funds from which labor services and associated benefits are paid. Various employee reports are available such as leave used, W-2 reports, name directories, individual employee reports, various fringe benefit and deduction reports, and needed quarterly reports. The system can handle salaried or wage-earning positions. Records of hours spent on various tasks can be kept for cost accounting.

The voter registration subsystem is used to maintain a county voter registration file. It is used to print primary and general election registration lists, to print city and special district nonpartisan or partisan lists, and to abstract voter rolls by voting precinct and by political party.

The complete system has been in use by Ellis County for nearly two years. It is being implemented in another Kansas county which is changing from a completely manual system. That implementation experience shows the need to provide substantial training and assistance for the county to adopt the system smoothly.

Economists' Role in System Design

During our work, we have observed that the design and development of the management information systems for local governments have received little attention from economists, even though much of what such systems are about is in the purview of economics. Such systems are concerned about resources used and products produced, about providing incentives to participants to do what furthers objectives of the entity as determined by the public-choice process, about information flows required to obtain desired coordination among elements of the entity, and about public information needed for enlightened public choice.

The foundation for the design of a management information system is the description of local governments, including crucial characteristics of the local government, the political process by which decisions are made, the internal and external management information needs, the information necessary to determine—at least to encourage—efficient production, and the gamut of alternative arrangements by which a public service might be provided or a social objective met.

The study of local government, public choice procedures, and management needs involves political science and economics. From them is determined the management information needed—that for internal management and that for citizen action in the decision-making processes. The internal and external information desirable should include information regarding the efficiency of resource use. Here the issues of resource use, labor specification, capital intensity, employee incentives, alternative production techniques, and the objective functions of each participant in the operation are important.

Better cost information permits local governments to choose among a wider range of alternative ways to obtain a public service economically, such as by contracting with a private firm or with another local government for the service.

While information is useful, all is not of equal value. Information should be produced to the point where the marginal value of the last unit produced is equal to the marginal cost to produce it. At least it should remind us that more information may not be good.

Most management information systems are now computerized, and the complexity of computer programming deters the study of management information systems by those not proficient in computer programming. But the role of the computer in a management information system is just to capture, store, manipulate, and print or retrieve information. The computer is used because it can handle large volumes of data cheaply. Management information system design and requirements can be specified without a computer. Manual prototypes can be used initially to illustrate the steps: how and when data are to be captured, how and when data are to be stored, and how

the data are to be retrieved and used. Once those have been specified, a computer specialist can prepare programs to do those jobs.

Economists have a useful role to play in the design of management information systems for local governments. New management information systems should enhance the capacity of local governments. That potential is more significant now that local governments may receive less federal money. But the development of such systems takes time and an understanding of the role of the management information system in governmental operations. By working with political scientists, management experts, and computer specialists, better designed and more comprehensive systems can be developed to meet challenges facing local governments.

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Decision Aids for Local Decision Making

Gerald A. Doeksen and James R. Nelson

Rural areas and small communities had a higher population growth rate during the 70s than metropolitan communities. This is the first time this had occurred in 160 years. Preliminary 1980 census figures indicate that nonmetropolitan counties increased in population by about 15%, whereas metropolitan counties increased by about 9% from 1970–80. However, rural growth has occurred selectively. Many mining, resort-retirement, and urban fringe counties grew by 40% or more in the 70s. On the other hand, nearly 500 of the 2,485 nonmetropolitan counties continued to decline in population during the same period (Secretary of Agriculture).

Decision makers in rapidly growing counties or communities are faced with the task of planning for growth. This includes estimating future growth and associated needs for community services so that sufficient capacity can be built into public service systems. Decision makers in declining areas face an equally difficult task of maintaining services for their constituents. Many of these communities are in heavily agricultural areas and lack alternative sources of employment. The reduction of population often leads to a decline in the economic base and in resources to support services.

Decision makers in both growing and declining rural areas need assistance in planning to accommodate change. A program to provide such assistance is ongoing at Oklahoma State University (OSU). Rural development decision aids developed and utilized at OSU fall into three main areas and include (*a*) prediction of growth or analysis of impacts of changes in economic base, (*b*) derivation of budgets for alternative community service delivery service systems, and (*c*) generation of information in administration of delivery systems.

If such decision aids are to be developed and maintained for use by extension personnel, it is imperative that a strong research base be available to keep the research current and to develop new decision aids. The objectives of this paper are (*a*) to discuss each of the types of decision aids specified above, (*b*) to review the importance of a solid research base in the development and maintenance of such decision aids, and (*c*) to discuss extension delivery techniques for rural development decision aids.

Decision Aids to Predict Growth

For long- and short-range planning of community services, it is important that local decision makers have the best employment, income, and population estimates available. A mistake of building a water or sewer treatment plant too small or too large can be costly and embarrassing to elected officials. They need the best estimates with which we can provide them.

Many community service needs are a function of the age of the population. For example, the number of school children in a community can be estimated from information on the number of children by age category. For these purposes, a demographic model that includes components of births, deaths, and migration can be used. Migration is difficult to predict, but historical migration can be projected in lieu of more appropriate information.

If there is a change in the economic base or the structure of a community, more detailed models may be needed. Some of these include economic base, input-output, from-to, dynamic input-output, or simulation. Shaffer developed a local development model understandable by local decision makers. Applicability of Shaffer's work has been proven by the widespread adoption of the basic model. Similar models were computerized by personnel at the University of Florida, Purdue, South Dakota State, and Texas A&M.

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Presently, at OSU, we are using an input-output model and community service use coefficients as decision aids in long-range rural development planning. An example of an application of our decision aids is a recent study for Weleetka, Oklahoma (Lenard, Doeksen, Hodges). A new electrical equipment-manufacturing plant is scheduled to employ 52 workers in 1981, 122 in 1982, and 175 in 1983. An input-output model was used to predict the secondary impact for employment and income. The employment estimates are presented in table 1. Based on local conditions, such as unemployment and family size, population changes were also projected.

In addition, the impacts these changes have on community services were projected. Examples of impacts on community services are presented in table 2. Estimates were made of sewer needs, fire calls, hospital bed days, physician office visits, solid waste generation, and school taxes which would be attributable to the new plant. Local leaders used the estimates to evaluate the adequacies of local community services.

As researchers, we need to continue to improve our basic models and as extension workers we need to relay the needs as we perceive them from the user level to researchers. Our local level background has convinced us of needs for (*a*) more in-depth localized information about the impacts of economic change and (*b*) more information about the dynamic impacts of development or decline. Researchers are moving in this direction. An example is the regional model developed to analyze coal development in North Dakota (Toman, Murdock, Hertsgaard). Murdock and Leistritz are refining this model to measure the economic and demographic impacts on three communities of a nuclear repository. A community simulation model is being developed at OSU (Woods and Doeksen). A gravity model is used to estimate the service area of a community; then location quotient and input-output techniques are combined to constitute an economic model. The economic portion of the model is made dynamic by a recursive system of equations which are driven by final demand-estimating equations. The demographic portion of the model is based on a population model employing births and deaths. Migration is used to fit the demographic portion with the economic portion of the model. The model predicts employment and income by industrial sector, population by age cohorts, community fiscal measures, and community service needs. Fiscal measures include the amount of revenue generated by source, such as sales tax or user charges. Community service information includes predictions of needs for water, sewer,

Table 1. Estimated Employment and Population Changes from the Proposed Plant Locating in Weleetka

	Years		
	1981	1982	1983
Estimated employment changes by sector			
New electrical machinery manufacturing	52	122	175
Construction	2	5	7
Transportation, communications and utilities	3	8	11
Wholesale and retail trade	12	28	41
Finance, insurance, real estate and business and personal services	10	24	34
Professional and related services	21	50	72
Public administration	10	22	32
Estimated total employment	110	259	372
Population changes			
New electrical machinery manufacturing employees and their families	21	44	62
Persons employed in other new jobs and their families	21	48	71
Total population	42	92	133
Estimated number of new households	13	31	45

Source: Lenard, Doeksen, Hodges.

Table 2. Examples of Impacts on Community Services Resulting from New Plant

Item	1981	1982	1983
Number of new school children	16	34	49
Additional water needs (gallons)	1,076,400	2,566,800	3,726,000
Additional ambulance calls	2	3	5
Additional sales tax receipts	$5,958	$15,369	$24,294

Source: Lenard, Doeksen, Hodges.

solid waste, fire, ambulance, police, hospital beds, and physician visits.

Decision Aids to Evaluate Alternative Community Service Delivery Systems

The decision aids employed most frequently by Oklahoma rural development extension personnel are community service budgets. Farm management research and extension personnel have employed budgets for years and they are the foundation of many of their programs. Likewise, we have found that they are the cornerstone of our community service programs.

In Oklahoma, research and extension personnel in recent years have emphasized providing budgets for community services, and responses from local decision makers have been overwhelming. Now that local decision makers, state personnel, and others have become aware of our capabilities, requests for budget studies are almost more than personnel can handle. For example in 1980, Oklahoma Cooperative Extension Service personnel completed over 100 specific community service budget studies. These budget studies serve not only to build a clientele for rural development extension but also to provide a needed service. A recent letter from the mayor of Durant, Oklahoma, attests to this fact. The letter to Charles Browning, Dean of Agriculture, reads:

> We wish to express our appreciation of your fine staff and their report, in regard to the ambulance study for Bryan County. The data they collected and the information they presented will be most helpful in our determination of how to handle the situation. We will probably use their experience again at a later date.

To illustrate the results of a budget study, a recent emergency medical services (EMS) study will be summarized (Lenard et al. 1981). The research base for the extension application is found in an EMS handbook (Doeksen et al.).

The city council of Sayre, Oklahoma, requested a budget analysis of their emergency medical service. They were seeking the best delivery system for the least cost. The study included an analysis of all ambulance runs made during the preceding year. Data were analyzed by a computer program and calls were sorted by type, time of day, place of pick up, destination, response times, and other criteria. The information aids a system manager to plan for staffing and equipment needs.

Next, an estimate of future calls was made to give decision makers an idea of future capacity needs of the system. Methodolgy derived from the research project was used to estimate calls for 1981 (fig. 1). Ambulance calls were classified into three types: (*a*) highway accidents, (*b*) transfers, and (*c*) other medical calls. Highway accident calls were specified as a function of the number of autos and motorcycles in the service area. Transfer calls were defined as the movement of patients between hospitals and were specified as a function of the size and services of the local hospital, the local medical staff, and other medical factors. Transfers can be estimated from records of the local hospital. Other medical calls included all other calls and are generally for emergency reasons, such as heart attacks and strokes. These were found to be a function of age. Using nine age categories, utilization rates were derived which indicate the number of calls per 1,000 population. These utilization rates can be used with area population data to predict the number of other medical calls. By applying the methodology, 406 calls were estimated for the Sayre EMS in 1981. In addition, a demographic model was employed to estimate the population of the area from 1980–90. Using the methodology in Doeksen (1979) the number of EMS calls was projected. For example, there were projected to be 449 calls in 1985 and 498 calls in 1990.

The research base allows for the prediction

FORM I

Procedure Used to Estimate Number of Calls, Mileage and Receipts for Emergency Medical Service

Specify service area and community where ambulance is located.

Sayre and surrounding area

I. Estimate the number of calls for the service area

A. Estimated number of calls for highway accidents = 39

B. Estimated number of transfers (calls transferring patients between hospitals) = 78

C. Estimated number of other medical calls

population by age group	population of service area in thous.	no. of calls per thousands in each age group per year	no. of calls in each age group per year
below 20	1.792	8.57	15
20 - 29	.894	17.07	15
30 - 39	.741	13.66	10
40 - 49	.668	16.82	11
50 - 59	.679	28.04	19
60 - 64	.365	46.42	17
65 - 69	.363	59.91	22
70 - 79	.529	137.32	73
80 +	.418	255.10	107
		Total other medical calls	289

D. Total ambulance calls: 39 (highway calls) + 78 (transfer calls) + 289 (other medical calls) = 406

Figure 1. Application of EMS research to Sayre, Oklahoma

of costs and returns for alternative systems. Forms were derived for easy analysis and presentation. The summary form is presented in figure 2. The top portion of the form can be used to estimate receipts. For example, if a $55 base rate is charged plus $1 per mile one way and 70% of the patients pay their bills, $24,045.00 will be collected. Annual capital and operating costs for four alternative systems are summarized on the bottom portion of the form. The first alternative involves a system with volunteers and paid personnel. Total estimated annual costs equalled $56,674.98. The second and third alternatives include volunteer systems whereas the last is a hospital-based system.

In this example, if 70% of patients pay their bills and a $65 base charge plus $1 per mile is employed, none of the systems would break even. Another source of income or a subsidy of some sort is needed at the $65 base rate.

The budget analysis presents the alterna-

Table 3. Optimum Location, Response Time, and Annual Capital and Operating Costs for Two or Three Locations, Bryan County, Oklahoma

	First Choice		Second Choice	
Minimize response time to get to emergency				
Two locations	Bokchito, Durant		Colbert, Durant	
Three locations	Bokchito, Durant, Colbert		Bokchito, Durant, Colbert	
Distance to emergency (miles)	Maximum	Average	Maximum	Average
Two locations	23.5	2.4	37.5	2.45
Three locations	23.5	1.6	23.5	1.7

tives confronting the local decision makers. The alternatives are constructed to reflect their desires. In addition to EMS budget studies, extension personnel at OSU conduct budget studies for fire services, clinics, water delivery, solid waste disposal, transportation systems for the elderly, and sewage disposal (Doeksen and Nelson).

Decision Aids for Administration of Delivery Systems

As we worked with decision makers, requests involving other decision aids surfaced. In each case, research was undertaken to develop the aids that could be used in future applications. Requests surfaced concerning (*a*) optimum location of emergency equipment, (*b*) least-cost service routes, and (*c*) potential revenues associated with alternative rate structures. Each of these is discussed below.

Optimum Location of Emergency Equipment

The decision makers of Bryan County (Lenard et al. 1980) decided to create an EMS district to serve the entire county. Location of ambulances is critical to providing the best quality service. Local leaders requested a study to evaluate alternative locations. A general transportation model was used to minimize a linear objective function with respect to specific linear constraints (Oehrtman, Broeckelman, Doeksen). For Bryan County, there were seven possible ambulance locations. These were Caddo, Bokchito, Bennington, Durant, Calera, Colbert, and Achille. Once the supply points (locations) were designated, it was necessary to delineate demand areas. These were assumed to follow township lines within the county. This procedure resulted in the creation of thirty demand areas. Road miles from each of the seven supply points to the center of each demand point were computed to determine a mileage matrix. The remaining data needed by the location model are the number of annual calls for ambulance service expected from each demand area. These were estimated as a function of area populations. The computer model was run to determine the least-cost combination of locations.

If two locations are desired, the locations which yielded the lowest estimated average response time are Bokchito and Durant (table 3). By having vehicles at these locations, the estimated average response in miles was 2.4 miles and the maximum was 23.5 miles. The three locations to minimize average response time were Bokchito, Durant, and Colbert. Estimated average miles to an emergency dropped to 1.6, whereas the estimated maximum distance remained unchanged. First- and second-choice solutions are presented. In addition to providing quality of service data as reflected in the response times, costs are estimated for each system. The annual cost of providing service from two locations was estimated as $167,519, whereas the annual cost if service is provided from three locations was estimated as $187,618. Local decision makers must decide whether the increased cost is worth the reduction in response time.

Least-Cost Service Routes

Another decision aid which was developed to meet local requests is a routing model (Oehrtman, Broeckelman, Doeksen). Requests have been received concerning appropriate routes for solid waste trucks and school buses. A recent example of applying the problem to a school system with 102 bus stops to pick up 219 children is used to illustrate the model. Each bus has a capacity of 48 children; therefore, assuming one route per bus, five buses would be required to transport the children from their homes to school and vice versa.

All bus stops were numbered, and the num-

Form II
Procedure Used to Compare Estimated Annual Receipts and Costs for Alternative Ambulance Delivery System

	Alternative Fee Rates			
I. Estimated Receipts	$45	$55	$65	$75
Ambulance Fee $___ x (___number of calls) =	18,270	22,330	26,390	30,450
Mileage Fee ($1 per mile one way)	12,020	12,020	12,020	12,020
Total Receipts	30,290	34,350	38,410	42,470
Receipts at 70% payment	21,203	24,045	26,887	29,729
Receipts at 60% payment	18,174	20,610	23,046	25,482
II. Estimated Costs	1st alternative	2nd alternative	3rd alternative	4th alternative
Specify vehicle	Hightop 2 Vans	Hightop 2 Vans	Hightop 2 Vans	Hightop 2 Vans
Communication system	VHF	VHF	VHF	VHF
Labor system	Partially Paid	Volunteer	Volunteer	Hospital
A. Capital expenditures				
Vehicle depreciation	$8,145.00	$8,145.00	$8,145.00	$8,145.00
Communication (Base)	$563.50	$563.50	$563.50	$563.50
Communication (Vehicle)	$530.00	$530.00	$530.00	$530.00
Building Depreciation	$3470.00	$3,470.00	$3,470.00	$3,470.00
Pagers	$530.60	$530.60	$530.60	$530.60
Interest	$_____	$_____	$_____	$_____
Subtotal	$13,239.10	$13,239.10	$13,239.10	$13,239.10
B. Operating Expenses				
Vehicle	$8,531.50	$8,531.50	$8,531.50	$8,531.50
Communication	$450.00	$450.00	$450.00	$450.00
Building	$1862.88	$1862.88	$1862.88	$1862.88
Medical	$3755.50	$3,755.50	$3,755.50	$3,755.50
Subtotal	$14,605.88	$14,605.88	$14,605.88	$14,605.88
C. Labor costs Subtotal	$28,330.	$9,366.	$7,300.	$23,460.
D. Training cost	$250.00	$250.00	$250.00	$250.00
E. Miscellaneous	$250.00	$250.00	$250.00	$250.00
Total	$56,674.98	$37,710.98	$35,644.98	$51,804.98

Figure 2. Summary form of EMS alternatives facing decision makers in Sayre, Oklahoma

ber of children to be picked up at each stop was indicated. In addition, a mileage matrix was specified which indicated the miles from each bus stop to each other bus stop. The computer routing program was then used to select the five routes which would minimize miles traveled without exceeding bus capacity or time limits. The five routes specified by the computer program minimize the mileage traveled by the five buses.

A Utility Rate Structure Model

The estimation of revenues associated with community services that have complicated rate structures (such as water systems) can be

a rather complex procedure. A computer program was developed at Oklahoma State University for this purpose.

In order to make the program operable, data must be input on number of users and consumption by user for each month in a year. Alternative rate structures can then be specified and the computer will calculate total revenues which would be generated from these users from each rate structure alternative (Nelson et al.).

Decision makers for Ottawa County Rural Water District Number 2 in northeastern Oklahoma requested assistance from the Cooperative Extension Service in estimating revenues which they might expect from alternative rate structures. They wished to compare these revenues with estimates of costs for upgrading their system. The decision makers provided appropriate data on system use.

Computer outputs such as the one shown in table 4 were then generated for several rate structures. Water district decision makers used this information to set new water rates.

Importance of a Research Base

An extension program which delivers decision aids to local leaders needs a strong and continuing research base. Rural development researchers need to continue (*a*) improving decision aids by better prediction of community growth and decline and evaluation of impacts, (*b*) updating and improving community service budgets and analyses, and (*c*) providing new decision aids as new problems surface. A community simulation model is needed which is sensitive to many local issues and can predict important variables over time.

Concerning our community service budget analysis, much research work remains. Specific needs are (*a*) to provide better demand or usage coefficients, (*b*) to determine if a service is price elastic or inelastic, (*c*) to estimate economies of size, (*d*) to estimate at what usage levels additional capital inputs are needed, (*e*) to provide quality of service measurements, and (*f*) to continually update budget data.

The Delivery Process

Other than the usual procedure of having the requests go through the county extension director with assistance provided by the area and state rural development specialist, several features are thought to be critical to successful delivery of rural development decision aids by Oklahoma Cooperative Extension. These include (*a*) a team effort involving all related agencies, (*b*) rapid responses to requests, and (*c*) specific community reports. When a request is received, OSU personnel involve all related agencies. For example, if an emergency medical service request arises, personnel from the State Health Department, State Highway Department, Health Systems Agency and Sub-State Planning District be-

Table 4. Total Water Sales (Dollars) by Month and Use Class

Month	Less Than 1,500	1500 to 4,500	4500 to 6,500	6500 to 10,000	More Than 10,000	Total
January	803	1,281	398	293	125	2,899
February	548	565	457	799	1,979	4,347
March	638	883	677	489	726	3,412
April	585	750	604	866	1,144	3,948
May	525	784	716	753	1,051	3,831
June	510	761	559	929	815	3,574
July	503	620	711	965	878	3,677
August	548	601	562	1,054	1,055	3,820
September	578	750	666	826	838	3,657
October	623	534	661	943	971	3,731
November	683	757	639	777	609	3,464
December	660	925	675	660	446	3,366
Average	600	768	610	779	887	3,644
Total annual: $43,732						

Note: Information is based on the following price scheme: under 1,500 gallons: flat rate of $7.50; next 3,000 gallons are charged at $0.110 per 100 gallons; next 2,000 gallons are charged at $0.080 per 100 gallons; next 3,500 gallons are charged at $0.075 per 100 gallons; above 10,000 gallons charged at $0.070 per 100 gallons.

come part of a response team. Each agency has expertise to contribute to the solution of a community problem. Community leaders are impressed by such joint efforts and recognize to whom they may turn if questions arise in specific areas. Since this approach is working, other agencies are aware of our contributions and often refer budget studies to us.

Local leaders appreciate quick response to their crises. Many of the studies have been computerized to facilitate rapid response (Nelson and Doeksen). The goal of extension personnel has been to complete a study within four weeks of the date the request is received. In addition, a computer terminal is often taken along to a community when a final report is delivered, so that other alternatives can be analyzed via telephone connection if community leaders so desire. The computer programs are written in interactive modes so they are easily used and understood by local leaders.

The last, unique aspect of the delivery process is to leave copies of final reports with community leaders. Reports include names, agencies, and telephone numbers of everyone involved with the report. Written reports are good advertisements for extension as leaders from other communities see the reports and become aware of the assistance which extension can provide.

These decision aids have built a strong and large clientele. Many community leaders have written the dean of agriculture or the president of the Oklahoma State University indicating their appreciation of extension's assistance. If we ever need someone to "go to bat" for rural development extension in Oklahoma, we are confident that the many community leaders for whom extension has worked will gladly support our programs.

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Management Information Systems for Local Government: Discussion

Steve W. Murray

Sjo and Biere have skillfully discussed a topic which is timely since there are intense public demands for more efficiency in the production and delivery of services by local governments, for a reduction in the size of public sector, and for an accompanying reduction in taxes. Community development researchers and extension personnel at land grant universities are concerned that local government officials in smaller cities trying to operate more efficiently may purchase expensive computer hardware and software which have limited applications in local government and may not provide government administrators and voters with useful information for making decisions.

A management information system must furnish relevant data in useful form to the right person at the right time for use in management decisions. Computers assist in the process but, as Sjo and Biere explain, the computer itself is not the management information system. To be effective the system must supply administrators with information they need to deliver services efficiently (an "internal" use) and it must transmit information about the cost of the services to the voters (an "external" use). Through the political process the mix and level of services can be adjusted so that the total utility of the community is maximized.

There are levels of sophistication of computerized management information systems. At the first level the computer does what was formerly done by hand or with noncomputerized equipment. Even though the size of the application might be quite large, this is still the lowest level of computer utilization. In this mode the computer functions as a high-speed adding machine and typewriter.

At the second level the computer is used to automate a portion of an agency's work. This includes the use of the computer as a low level decision maker in those instances where all the factors needed to make a decision can be programmed into the system and judgmental qualities are not needed. Examples of automated applications are the automatic sending of overdue or cutoff notices for delinquent utility bills, permit application renewals, and summonses for parking violations after prescribed periods of time.

At the third, and highest, level the computerized management information system reports to managers the types of analytical information that will help them in their work of decision making. The computer is used to make aggregations, summaries, and exception analyses for these purposes.

In most local governments the computer is used at the lowest level; Sjo and Biere challenge economists to see that higher utilization is attained. The economist must be a partner with the data-processing professional, the accountant, and the attorney in designing the management information system for local government. The first requirement is that the system maintain records which are required by federal, state, and local statute. This is a low level usage and the economists' contribution is limited at this stage.

The economists' contribution is critical at the third level—providing analytical information to government administrators and voters. Typical of the contributions the economist can make in the development of the management information system is clarifying the effect of depreciation and interest expense on the total cost of providing various services.

Sjo and Biere argue that local governments have no single objective measure of performance as do private firms. They maintain that profit is a reasonable measure of performance for private firms and question whether other measures are good substitutes. Local governments provide distinct services. Some of these services are readily available in both public and private sectors. Examples of ser-

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vices which are commonly provided by either sector are solid waste collection and disposal, road and street construction and maintenance, and emergency ambulance service; services commonly produced only by the local public sector are fire protection and operation of the polls. Local decision makers must routinely choose whether to provide public services such as those in the first category indirectly through contracts between the government and the private firms or directly by employees and equipment of the local government. The information the local decision maker needs is not related to profits, but rather to the total cost of providing the service by the government as opposed to the contract price charged by the suppliers of the service in the private sector.

The authors stress that there are fundamental differences in the objectives of managers of private firms and the objectives of administrators within local government organizations. For example, while the objective of the manager of a private firm may be to maximize profits, the companion objective of a public sector manager may be to provide adequate service while spending exactly the amount allocated to his department during the period covered by the government budget. The vendor of the computer must understand that objectives of government administrators differ from those of managers in private firms. Government officials must understand that software designed for private sector applications may not be useful in a government department.

Whether universities, the federal government, or private firms will lead in the development of computerized management information systems for local government is uncertain. Because of their training and contacts with local government, extension and research economists at land grant universities certainly can contribute to the development of local government management information systems.

Management Information Systems for Local Government: Discussion

Richard Barrows

Sjo and Biere have taken the initial steps in developing a conceptual framework relating management information systems (MIS), local government capacity building, and a general theory of local government behavior. To their credit, the authors avoid the common error of focusing on computer technology, technique, and case study examples rather than on the policy issue or problems MIS is designed to resolve. They have produced a thoughtful and stimulating paper.

My major criticism of the paper is simply that the analysis of the governmental setting for MIS was not sufficiently developed. This criticism is not entirely appropriate, given the constraints on the length of the paper and the initial stage of development of the conceptual framework. I will briefly extract what I believe to be the key points of their argument, suggest some modifications and avenues for expansion, and identify some implications for research and extension.

The authors note some critical differences between private businesses and local governments that affect adoption of MIS. Two of these differences form the basis for an argument that the neoclassical theory of the firm will not perform well when applied to local government decisions in general, and MIS in particular. They argue that for local governments, an "objective performance measure" analogous to profits for firms is lacking because of widely divergent views of what local government should do. A second important observation, that "local government decision making is a political process . . .", leads Sjo and Biere to the conclusion that various definitions of "capacity building" are inadequate because they are based on a concept of local government analogous to a private firm. They argue that the Robinson Crusoe example, in which consumption and production decisions are made in combination by a single entity, is a more appropriate conceptual model. However, they criticize this concept because it ignores the high degree of human interaction inherent in local government operation.

A generalized model of local government decision making is implicit in the paper, although it is never explicitly or fully developed. I will extend some of Sjo and Biere's arguments and outline a model similar to those developed recently in international relations in political science (Allison). Consider a local government which jointly makes consumption decisions (which services, how much, to whom, etc.) and production decisions (how to produce, by whom, what cost, etc.). Consider a political environment in which decisions are the result of the interaction of various interest groups, private organizations such as businesses, public organizations such as county departments, elected officials, and the "interested public." This interaction is structured according to some "rules of the game" which define the channel through which an action is taken. Action channels vary with the issue. For example, the action channel for a road construction project decision will be different from that for a federally financed sewer project. These decision-making rules place individuals or groups at key points in the process and partially define the power or access to power of individuals, interest groups, and organizations.

This rudimentary model can be applied to adoption of MIS. Sjo and Biere correctly note that those "external" to government bureaucracy are central in consumption decisions and that MIS must be designed to help citizens make collective decisions. (However, public agencies also participate in the consumption decisions). For a given consumption decision, it is possible to identify the action channel, the key actors along the channel, the private interest groups and organizations, and their

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interests. This should aid in a systematic identification of relevant information for a MIS system. For example, in Wisconsin county forest decisions, the relevant actors are the county board chairman and forestry committee, recreationists, loggers and wood industries, resort owners, and a state agency. Each group has some fairly well-defined interests that should be captured in any MIS design.

Production decisions are also best viewed as a political process. Adoption of a particular policy or action may simply shift the political struggle to the implementation front. Also, as Sjo and Biere note, production occurs in complex organizations and the theory of organizational behavior pioneered by Simon and others is relevant. In designing an MIS, it is important to understand both the local political process and decision making within complex organizations. (Sjo and Biere argue that the individual is the basic decision unit in production, not the local government. In small rural counties, where one individual may comprise an entire county department, this may be a useful simplification of organization theory, but in larger counties this may not work well.) Obviously, MIS also can assist in analyzing the efficiency or cost-effectiveness of production activities. However, if MIS is to be used to provide incentives for efficient production, then an understanding of how individuals act in complex organizations is required.

The view of MIS as a part of local government political processes suggests two obvious research needs—a conceptual model of the local government decision-making process and a model of behavior in complex organizations adapted to rural, small government conditions. Both types of research are well-suited to interdisciplinary work by economists and political scientists, as Sjo and Biere note. Extension economists also would benefit from research to identify the "key ingredients" for successful implementation of an MIS system. One key ingredient may be a strong incentive for local government to adopt MIS—in Ellis County, Kansas, it was evidently strong dissatisfaction with a new computer system. A strong incentive probably is needed to overcome the problem of short-run costs and long-run benefits from MIS, and the short-run nature of government budgets and the terms of elected officials. Another prerequisite may be strong support from top administrators and staff, and the incentive and ability to absorb the training necessary to make the MIS system work. Sjo and Biere's example also suggests that some outside support may be necessary at least in the first few years in the first counties to adopt MIS. The challenge for extension economists is ultimately to design a procedure for design of MIS which can be used by local governments or private firms without extensive university support.

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Decision Aids for Local Decision Making: Discussion

W. Arden Colette

The authors have done an excellent job of documenting what can be done and is being done to assist local decision makers. Their presentation refers to more than twenty alternative analyses they provide for both the private and the public sectors. The list of available decision aids is impressive and the developers of the programs should be complimented.

However, the state of knowledge is never static. There is always a search for a better mouse trap or a better model. The authors' list of research needs demonstrates the need for constant improvement. The development of more precise demand and usage coefficients, the computation of elasticities, the determination of economies of size and other economic measurements would be helpful in refining and improving the decision aid models.

The program described by the authors was developed and has been operated successfully in a system in which the extension specialist completes the analysis and presents the alternatives to the decision maker. However, they do not consider future trends in decision aid development and use nor do they address the implementation of programs under different extension philosophies or where personnel are limited.

Universities that are contemplating initiating or expanding their decision aid programs should answer four basic questions in their planning process. First, who will bear the costs of the program? The cost can be borne by the community that uses the decision aid (and thereby receives the benefit), by the state program, or it can be paid out of federal funds. The distribution of costs will affect the number and size distribution of communities that participate in the program. Second, will a fee be charged for the service or will the service be provided free? If a fee is charged, will it cover the cost of developing and using the aid or will the community pay only the variable costs? If the fee does not cover the entire cost, how is competition with private consultants to be evaluated? Third, will education or service be the basic extension philosophy of the program? In an educational program, the decision aids would be developed and local personnel trained to use them. In a more service-oriented program the analyses would be run by university personnel and only the alternative solutions presented to the decision makers. Fourth, what will be the level of service? Will the programs provide expertise by substituting for local planning departments or will it develop expertise by providing only supplemental information for professional planners?

The answers to these questions will go a long way in determining the types of decision aids to be developed, the form they should take, and personnel needs.

During the past few years computer technology has progressed so rapidly that independent computer systems are now within the financial reach of even the smallest planning department. Depending upon their size and the complexity of their tasks, decision makers can select between microcomputer, minicomputer, and main-frame computer systems. A leading planning consultant has predicted that during the 1980s the use of the personal computer will become standard in even the smallest planning office (Finn). Even at the current level of technology the microcomputer provides many alternatives for geographic-based data display, planning data analysis, office operations, and telecommunications.

Regardless of the method selected, the university has a role in satisfying those information needs that are beyond the scope of any single local planning department. Local planners look to the university to obtain population projections and other demographic infor-

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mation. There are also basic data sets that are needed by all planners. Basic technical relationships, such as school services requirements, housing services needs, water requirements, sewer generation, trip end generation, and secondary impact multipliers are common requirements of all planning units. The development and maintenance of these types of data sets should be one of the basic functions of every university program.

One of the main problems that every program must face is the development of receptive clientele and adequate support. Unlike Oklahoma, many programs have not been able to generate strong political support from clientele groups.

In summary, the paper is an excellent documentation of what can be done and how far decision aid development has advanced. However, it provides little insight into the future direction of decision aid development and program implementation. In expanding its program, each university must answer such questions as, Who will bear the cost of the program? Will the program be primarily educational or service oriented? What level of service will be provided? And, finally, how can strong clientele and financial support bases be built and maintained?

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Decision Aids for Local Decision Making: Discussion

Josef M. Broder

In this period of declining state and federal support for many local programs, local officials are given the formidable task of providing adequate levels of community services for localities which often exhibit unique and unpredictable growth patterns. More than before, local officials must assume the role of entrepreneurs in planning and implementing community service delivery systems. As with any type of management role, the local decision maker has an ever-increasing need for management information. The quality of a particular decision with regard to community service provision is only as good as the quality of the information available to the decision maker. Unfortunately, many small units or subunits of government have neither the information or the means of obtaining the information for making sound management decisions.

Realizing the importance of information to the local decision-making process, Doeksen and Nelson have developed an impressive program of decision aids for local decision making. The main thrust of their program is to assist rural areas in planning to accommodate change. Their program emphasizes three main areas which include decision aids (*a*) to predict growth, (*b*) to evaluate alternative community service delivery systems, and (*c*) to administer delivery systems. This discussion will attempt a brief assessment of the strengths and limitations of these decision aids. In conventional terms, area (*a*) is concerned with the demand side while areas (*b*) and (*c*) are concerned with the supply side of community service provision. Given the collective nature of community service provision, this discussion is written from a public choice perspective.

With respect to demand, the authors have indicated that population, employment, and income changes impact directly on the level and mix of community services. Local decision makers face a twofold challenge of satisfying the majority needs of current residents and planning for potential growth. The latter of these challenges appears to be the most troublesome. In planning for populations and industries which may (or may not) arrive at some future date, decision makers are faced with the problem of planning for option demand. Option demand is a special public goods problem associated with identifying and collecting a fee from individuals who will benefit at some future date from a public decision made today. For expanding communities, planning for option demand means designing and financing service delivery systems which exceed the effective demand of the current population. This task is further complicated by uncertainties as to the preferences of future residents which may differ from those of current residents. Reliable growth forecasts can reduce some potential overinvestments or underinvestments in service delivery systems.

On the supply of community services, Doekson and Nelson discussed decision aids to assist decision makers in evaluating and administering alternative systems. For this purpose, community service budgets were developed which enable decision makers to choose among alternative systems. Adopted from farm management budgets, community service budgets eliminate some of the guesswork associated with implementing or increasing the level of community services. Lacking the resources to generate budget information, local officials will be able to use these decision aids to provide services at lower costs. I was particularly impressed with the format and thoroughness of the budgets designed for ambulance delivery systems. Particularly noteworthy of these budgets are the decision options which are made available to decision makers. These options provide considerable flexibility for decison makers.

After adopting a service delivery system,

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decision makers need information on monitoring and modifying the system over time. To this end, research was undertaken to enable decision makers to determine optimum locations, least-cost service routes, and potential revenues. Optimum locations for emergency medical services were determined through a general transportation model. A computer routing program was developed to minimize travel costs for solid waste trucks and school buses. A computer program was developed to estimate potential revenues from alternative water rate structures.

Some major shortcomings of these decision aids were discussed by the authors in their needed research section. Among the more important were (*a*) the need to provide better demand estimates and (*b*) the need to provide quality of service measurements. Given a clearly defined objective function of maximizing revenues or minimizing costs, the service supply problem reduces to a farm management problem. However, when citizens disagree as to the proper level and mix of services, the process of community service provision may not be as simple as the authors have indicated.

A distinction is made in the public choice literature between production studies which establish physical input-output relationships and institutional studies which are concerned with conflicts over output definition under alternative institutional settings. The decision aids developed by the authors are sufficient for identifying production relationships but are weak in assisting local decision makers to understand the community service demand-articulation process. Without a clear understanding of citizen preferences, local decision makers risk maximizing the level of community services citizens do not want. In addition to production studies, decision aids are needed which enable decision makers to identify citizen preferences.

The demand articulation process affects both the quantity and quality of community services. Service quality is a reflection of how well the level and content of a service meets the preferences of local citizens. Service quality is influenced by the preferences of citizens who have access to the community service production process. Changes in population likely will change the relative power of groups and their access to this process, and, thus, further complicate the task of providing quality services compatible with majority preferences. More research is needed on the impact of community growth on the service demand articulation process.

In conclusion, local decision makers also need decision aids that enable them to identify changes in community preferences and adjust the level and mix of community services accordingly. These decision aids can take the form of preference surveys of the type used by national level decision makers to identify majority preferences on a particular issue. Survey technologies can be readily adapted to the local level. The development of local preference surveys as decision aids will further enhance the decision maker's ability to provide community services which are consistent with local needs.

panels and an advisory committee were formed. The study was organized around three areas: (*a*) management of food and agricultural research, (*b*) structure of food and agricultural research, and (*c*) determination of food and agricultural research priorities.

A work group of nationally recognized professionals was formed for each of the three areas. The work groups identified the topics of the commissioned papers, advised on the major components of each paper, and recommended authors. Each work group also reviewed the papers and drafts of the final report.

An overall advisory committee also was selected. It included research professionals and representatives from sectors affected by food and agricultural research—farmers, processors, retailers, labor, and consumers. The advisory committee provided overall guidance to OTA on issues to be analyzed, and it reviewed all commissioned papers and drafts of the final report.

Although the report does not focus on agricultural economics per se, there are a number of observations that can be made about the role of agricultural economists in the broader area of agricultural research. The remaining discussion will delineate the contributions by agricultural economists to the study, discuss some of the general findings of the study that have relevance to agricultural economics, and discuss implications for the agricultural economics profession.

Contributions of Agricultural Economists to the Study

The major contributions of agricultural economists to the OTA study were in three main areas.

First, an economist with a strong interest in agricultural history traced USDA and state research institutional developments and showed their growth and interaction over time.

Second, agricultural economists were responsible for (*a*) analyzing the funding of agricultural research; (*b*) analyzing the costs, benefits, and burdens of agricultural research; and (*c*) developing methodologies to measure the quality of research. Under (*b*), agricultural economists analyzed the nature of research benefits, examined the distribution of benefits and burdens, studied the relationship between benefits and funding sources, and measured the economic returns to research investment. Under (*c*), agricultural economists attempted to develop better methodologies for measuring the quality of research through the use of publication citations in peer-reviewed journals and the granting of patents. A great deal of research will be needed before these or any other measurements of research quality can be used, if they can be used at all.

Third, agricultural economists evaluated methodologies for determining research priorities. Existing methodologies—for example, those used in the World Food and Nutrition Study—were evaluated according to their strengths and weaknesses. Again, it became evident that more research is needed to develop methodologies for setting research priorities and to assess the impacts of the research.

In general, we were somewhat surprised by the relatively limited amount of research on the social, economic, technological, and other impacts of agricultural research in the United States. We particularly have in mind rate of return, or cost-benefit analysis, and development of methods for measuring priorities. Much of the major existing work concerns foreign agriculture; the relative neglect of the United States is rather odd, considering the early work of Griliches and the University of Minnesota research conference held in 1969 (Fishel). Much of the work reported at a recent Minnesota conference for this country (*Evaluation of Agricultural Research*) was of a scattered nature and recent vintage. Research on the impacts of agricultural research in the United States does not seem to yet be a main line of activity in the profession.

Assessment References to Agricultural Economics

The assessment made a number of findings. Although economics research was not a main focus of the study, it did come in for some attention. Those findings of particular interest and with implications for economics research are briefly noted here. They are in the areas of funding, roles of research participants, management of research, and research priorities determination.

Funding

Despite the fact the USDA was a pioneer and long a leader in research in the U.S. government, the present situation is quite different.

Recent USDA research expenditures have been the smallest of any major federal research agency. In 1978, USDA's share of federal research expenditures was only 1.5%. This compares as follows: Department of Defense, 45%; Department of Energy, 16%; and Department of Health and Human Services, 12%.

The purchasing power of total USDA and SAES agricultural research expenditures increased 23% in constant dollars from 1966 to 1979. The pattern, however, differed sharply by component: USDA expenditures increased only 1%, while those of SAES increased 40%.

Private industry agricultural research is a major contributor to total food and agricultural research in the United States. Total expenditures by private enterprise for food and agricultural research are about three-quarters of the expenditures of state and federal government combined.

Within the total research budget of USDA (excluding funds passed on to the states), economics research as represented by the Economic Research Service (ERS) occupies a relatively small role. From 1972 to 1980, it accounted for only about 5.5% of USDA research expenditures.

Economics research typically has not been strongly favored by the agricultural committees in Congress. Other forms of social science research have been even less favored. Congressional disfavor originated with early efforts by the Bureau of Agricultural Economics (BAE) to be a general planning agency for the department. This proved to be highly controversial and was gradually cut back. From 1953 to 1961, economics research was split between and assigned to the Agricultural Research Service and the Agricultural Marketing Service.

In 1961, agricultural economics research was regrouped into the Economic Research Service and the Statistical Reporting Service (SRS). While the new arrangement was quite attractive to many agricultural economists, it did not find great favor in Congress. When Willard Cochrane, the first Director of Agricultural Economics, left in 1964, he said that without strong support from the Secretary, ERS would have a difficult time surviving, in part because "ERS had no pressure group "You insist on having a Bureau of Agricultural Economics. It is my judgment it costs you about a million or a million and a half dollars a year to carry that title, because it is hard to sell" (Baker and Rasmussen, p. 67).

Only rarely did an appropriation that increased funding for a particular line of economics research get through the Congress. As for the regular ERS budget, Congress continued to be critical. "The administrator sometimes seemed to be on a treadmill where great effort was required merely to remain in place" (Baker and Rasmussen, p. 68).

In fact, economics research funding through ERS has not even done that well. From 1966 to 1979, current dollar expenditures by ERS increased rather steadily from \$16.3 to \$37.1 million, or 127%. However, this increase did not keep up with inflation during the period, and in constant dollars there was an 8% decrease from 1966 to 1979.[1]

Moreover, of the roughly 5.5% of the Department's own research budget for 1972 to 1980 that was spent by ERS, only part was spent on research as such. ERS estimates that in FY 1980 only 35% of its funds went for research, 47% for analysis, and 18% for data acquisition. If these proportions are applied to the FY 1980 budget, it means that only 2% was spent on economics research and that the other 3.5% was spent on economic-related activities. There are no widely accepted norms in these matters, but this does seem a very small proportion for economics research.

The economics departments in the colleges of agriculture at the land grant universities have not fared much better. Economics research has remained at about 7.3% of total funding for all agricultural research in the United States since 1970. Other social science research has accounted for 2.0% of total expenditures, while biological and physical science research has received 89.9% of the total expenditures within the USDA and state agricultural experiment stations.

Roles of Research Participants

There is an important role for a strong national research program funded by USDA. This role has been carried out in the past by the Agricul-

tural Research Service (for a while known as SEA-AR[2]), Economic Research Service, and federal funding to state agricultural experiment stations. Historically, the ARS role was associated with broad regional, national, and international activities. The role of SAES, insofar as federal funds are concerned, has been primarily for local, state, and regional problems.

Within agricultural economics research, there has been very little discussion on the roles of the major public participants—ERS and university departments of agricultural economics. ERS convened a national committee of department chairmen and researchers in August 1979 to discuss mutual problems and interests. One issue was a perceived misunderstanding about similarities and differences in the role of ERS and university departments of agricultural economics. This lack of understanding was viewed as a barrier to improving the linkages and communication between ERS and universities. Several stereotypical descriptions indicated the differing perceptions of the group: (*a*) ERS works on national problems, and universities work on local and regional problems. (*b*) Universities work on micro problems and ERS on macro problems. (*c*) Universities should conduct basic and methodological research, and ERS should conduct applied research. (*d*) ERS serves national policy maker clientele, and universities serve farmers and state policy makers.

It is clear that the agricultural economics profession is not in agreement on what the roles are or should be for ERS and the universities. A clarification of roles should make it easier to identify areas of mutual interest and facilitate productive cooperative research.

As an example of the delineation of roles, there is no question that there is a role for a strong national USDA research program in the physical and biological sciences in food and agriculture. There are some implementation problems; but when the system is working properly, federal funds allocated to ARS are primarily for problems of regional or national importance where (*a*) the nature and/or magnitude of the problem is such that a single state cannot provide the resources for its solutions, (*b*) ... concerns for the problems, or (*c*) from an industrial standpoint, where the risk is too high or too demanding for any one industrial component. ARS is also responsible for research needs of action agencies within USDA. In addition, it is responsible and accountable to both the executive and legislative branches of government for the administration and national coordination of such programs. ARS leaves to the states those local, state, and site-specific problems that can be handled by the SAES.

SAES, insofar as formula funds are concerned, have primary responsibilities for state or local problems. SAES are concerned with problems of a regional, national, and/or international nature that are an extension of their state and local problems. But where ARS has active regional and/or national programs, such programs are developed cooperatively.

Agricultural economists need to debate the merits of a similar demarcation between ERS and universities. There have been no follow-up activities since the 1979 meeting. The tightening of federal funds in social science research will no doubt force this type of debate as appropriations committees demand a more efficient and coordinated approach to research.

Management of Research

During the long existence of the Bureau of Agricultural Economics and since 1961, agricultural economics research has been a separate research component in USDA. (Between the two periods most of the economics research was integrated into the Agricultural Research Service and the Agricultural Marketing Service). University departments of agricultural economics are also organized separately from the other disciplines. One result from this type of organization has been some isolation from the rest of the agricultural research community.

The discovery of new knowledge does not come as easily and in such small disciplinary packages as it once did. Modern agricultural research tends to be mission-oriented and multidisciplinary—involving the commitment

between ERS and ARS.[3] In fact, with the exception of some ad hoc groups that meet sporadically, there is no coodinating mechanism for planning and conducting multidisciplinary research between ERS and ARS.

There may be more opportunities for disciplinary blending at the land grant universities. Certainly one would expect the SAES to try to encourage it. But on the other hand, the disciplinary walls established in graduate programs, where much of the research is done, can mitigate against the needed blending, and the research problems may be bigger than can be handled by the usual Ph.D. program. Thus it may be, as Paarlberg has suggested, that land grant universities have not organized themselves to combine well in a modern setting the two functions of developing agricultural economists and discovering new knowledge.

To obtain increased federal support in the future, something more may be required than the greater lobbying effort of the past. Coordination of research among the scientific disciplines needs increased attention.

Research Priorities Determination

At present there is no continuous long-term systematic planning process for food and agricultural research. Decisions are made on an ad hoc basis with very little coordination among the USDA, SAES, and other federal and nonfederal agencies conducting food and agricultural research.

Systematic determination of research priorities is important. Some research needs must be given higher priority than others. Requests for across-the-board increases for each scientific discipline will not be convincing to the appropriations committees. In fact, such requests have disillusioned them in the past. Such requests appear as more of a defense of the research bureaucracy than an earnest effort to solve the most important food and agricultural problems.

Many planning efforts exist, but none address the total spectrum of agricultural research as a unit. For example, the USDA and the land grant universities, under the auspices of ARPAC, had a system of regional and national research planning committees to identify needs in all areas of food and agriculture. However, the classification system used did not delineate the economics problems per se and, consequently, it is not possible to compare planned research with research needs for economics. Further, there has been no improvement in interfacing economics research with the total agricultural research planning of the Joint Council.

Congress established the Joint Council on Food and Agricultural Science and the National Agricultural Research and Extension Users Advisory Board to aid in coordination and priority setting. These groups have struggled with their assignments. The Joint Council has had difficulty organizing for its responsibilities, and the impact of the Users Advisory Board is unclear. Neither of these organizations has the capability to conduct a long-range systematic study of research priorities that involves scientists, research administrators, users, and consumers.

Involvement of the above participants is critical to the establishment of priorities. Scientists and research administrators are needed for the obvious reason that they have the expertise and are the performers of the research. The users of the research are needed because they have specific problems that need to be addressed by research. Consumers and other groups, such as labor, are an important aspect because they are affected by the research. Their voices have not been heard in the past and they have legitimate research concerns that the research community needs to address.

Long-term research planning can be accomplished by an intensive, comprehensive study involving the above participants. Such a study could involve the use of methodologies such as those pioneered by the National Academy of Sciences World Food and Nutrition study for priority determination. It might be updated every four years with a final report delivery date of 1 December of the year of each presidential election.

Priorities established in the long-range study could serve as the basis for authorization and budget hearings with the Congress and give direction to the total research effort.

Similarly, in the agricultural economics profession there have been little, if any, collective and systematic identification and prioritization of important problems. Individual researchers and individual research organizations give attention to emerging issues and to research that will be needed to address them. But there is no systematic process to coordinate these efforts

[3] ERS does include some research in the other social sciences (particularly rural sociology) and in history, but not a great deal

among institutions and individual researchers nor to see how much agreement or disagreement there is on what should be the future research agenda.

Agricultural economists evidently have never developed a process for problem identification in agricultural economics research. Agricultural economists should seriously consider initiating a major effort to identify emerging issues and economic research needs. Some proposed initiatives have been discussed, but they need to be given much more consideration.

Some Implications for Agricultural Economists

In the course of the OTA study, we gained some impressions about the role of agricultural economists in the broader arena of agricultural research. They might be considered hypotheses which require further discussion and testing.

The first overriding impression, already noted, is the need for much more research on the impacts of agricultural research by the profession. Curiously, the field did not originate in USDA or in the land grant colleges, but rather at a private city university, the University of Chicago. And most of the early practitioners were either former Chicago students who found positions at land grant colleges or students of former Chicago students. The field has grown some in recent years, but outside of a couple of universities it is principally composed of a few scattered individuals. ERS is still doing virtually nothing directly in the area (although it helps generate some of the data needed for such analyses). It is vital that more effort and resources be devoted to this line of work if we are to better understand and measure the contributions of agricultural research.

A second impression is that agricultural economists have been too insular; they are too isolated from the rest of the agricultural research community. We must note immediately that there are numerous individual exceptions. But, as a whole, it appears that many members of the profession do not have close ties with scientists outside their departments. We suggest that agricultural economists need to work closely with other social sciences and the humanities and with the biological sciences. We hear of interdisciplinary work, but we do not see much of it.

Agricultural economists, along with a relatively few rural sociologists, are virtually the only social scientists normally to be found within the public agricultural research structure. The other social sciences have significant contributions to make: we have in mind anthropology, geography, history, philosophy, and political science. Yet no agricultural college has a significant commitment to these subjects: at most, there may be one or two persons in these fields elsewhere in the university with an interest in agriculture.[4] They seldom receive any funding from the agricultural experiment station.

This situation probably reflects a lack of understanding about the potential contributions of these disciplines to agriculture and concern with possible legislative reaction on the part of research administrators. But even agricultural economists, who might be expected to be somewhat broader in their outlook toward other social sciences, have not appeared to be forthcoming. There seems to be little or no effort to build a more broadly based and integrated rural social science.

The agricultural economics profession as a whole, in general, also appears to have surprisingly limited links with the biological and physical sciences related to agriculture. This may be seen in the relatively limited interchange between agricultural economists and agricultural scientists at land grant universities and within USDA (ERS is particularly guilty). Agricultural economists seldom draw on biological scientists for insights or work closely with them in structuring their work.

One would expect a fair amount of agriculture in agricultural economics. This seems to become less so over time. Knowledge of agriculture and agricultural science almost appears to be of decreasing importance in the profession. At one time there was not very much economics in agricultural economics; now there is often relatively little agriculture. As we have become purer economists as a profession, we also stand in danger of becoming less useful to agriculture.

In generalizing about the relative scientific isolation of many agricultural economists, we must acknowledge that there are numerous individual exceptions. Groups are more difficult to identify. One group has done exceptionally well—the agricultural economists

[4] The Food Research Institute at Stanford, a private institution, has long found a place for demographers and geographers among its economists. On the other hand, it has no biological scientists.

at several of the international agricultural research centers sponsored by the Consultative Group on International Agricultural Research.

These institutions are primarily biological research organizations. Economists were added gradually and gingerly. The economist was initially alone, or virtually so, in a sea of biologists. He had to talk with them and work with them. The center director was primarily interested in what the economist contributed to the direction and conduct of the overall research program. The economist had to adapt to a new and rather strange world. And to the surprise of many, he did. More economists were added and their influence has grown. And some have had their work recognized in the form of awards from this association.

Moreover, some of the centers have recognized the importance of other social sciences and have gradually begun to add other social scientists, particularly anthropologists. One center has renamed its broadened economics unit the Social Science Department.[5]

One of the main themes of the international section of the overall OTA report is that the United States has much that it will be able to learn from the expanding program of agricultural research elsewhere in the world. This may also be true of agricultural economics.

Concluding Remarks

There is concern in Congress that all is not well in the food and agricultural research sector. This concern resulted in a request by the Congress for the Office of Technology Assessment to conduct an in-depth study. Many of the study's findings have implications for agricultural economists. Generally there is a need for more research on research and development of methodologies for measuring priorities. There is a need for delineating the roles of the university departments of agricultural economics and that of the Economic Research Service. There is also a need for greater involvement between agricultural economists and other social and biological scientists in the agricultural experiment stations and in USDA. Agricultural economists need to work together in a systematic manner on what the research priorities are for economic research and develop a mechanism to follow through on the identified priorities.

AAEA provides an excellent forum to discuss these issues. In particular, the AAEA could organize a session at a future meeting that would focus on future food and agricultural problems, the agricultural economics research needed to provide solutions to these problems, and the roles of the research participants. These are important concerns, particularly in times of low-level funding for research. Decisions in these areas will be made. Agricultural economists need to decide whether they want to be a part of the decision-making process.

[5] Of course, not all the needed research in the international agricultural research system can be done at individual biologically oriented centers. Policy research requires a broader perspective and is carried out in a separate International Food Policy Research Institute in Washington, D.C., headed by John Mellor. This group is predominantly composed of economists.

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Research and the Family Farm: Implications for Agricultural Economics Research

Lee M. Day

During the last half of the Carter administration, then Secretary of Agriculture Bergland was reasonably successful in bringing concerns about the structure of agriculture to center stage. The 1980 election appears to have lowered the place of structural concerns on the near-term policy agenda. But structural issues have been around a long time and can be expected to remain a concern of policy makers.

This paper deals with only a part of the total set of structural issues, that part dealing with the concentration of production on larger farms. In the spring of 1980, the Experiment Station Committee on Policy (ESCOP), conscious of allegations that too much of the research in the state agricultural experiment stations was of a type that was most applicable to large farms, sought a perspective on how the current structure of farming had evolved and an assessment of the role of the state agricultural experiment stations in bringing about changes in the structure of farming. ESCOP turned to a task force to develop these perspectives (Experiment Station Committee on Policy).

Chronologically speaking, the first activity of the task force was to attempt to determine the nature of research in the agricultural experiment station system with respect to possible contributions to the changing structure of farming. A 10% random sample of agricultural experiment station projects in the CRIS system was drawn. Fiscal year 1979 funded projects in both 1862 and 1890 institutions were included. Specifically excluded from that population were research projects conducted by SEA/AR, Economics Statistics Cooperatives Service, U.S. Department of Agriculture, and the research conducted by forestry and veterinary schools in the states. Directors of the originating stations were asked to classify their sample projects into one of five major categories related to agricultural production, processing and marketing, family living, community, and other.

For the first two major categories, the directors were asked to allocate the scientific year (SY) effort on the research projects among six subcategories: (*a*) basic research, (*b*) primarily useful to public bodies (e.g., agencies of federal or state governments), (*c*) oriented to small farms, (*d*) oriented to moderate-sized farms, (*e*) oriented to large farms, and (*f*) research equally applicable to all sizes of farms.

The definitions of small-, moderate-, and large-sized farms are, of course, arbitrary. We chose the gross sales measure in the belief that it is the best single measure available. Admittedly, such a measure is influenced by inflation. Also, such a measure treats different types of farms unequally. Contrast, for example, a cash-grain farm and a feed-lot operation where a major proportion of the latter's gross sales is represented by the purchase of feeder steers. The definition of small farms, under $20,000 of gross sales, was based on congressional action (the Rural Development Act of 1972, as amended). The upper limit of the moderate-sized farm at under $100,000 was based on the belief that most of the economies of size have been captured by farms of that size or smaller. All farms with sales of more than $100,000 were considered large farms.

The classification of research is by no means an exact science, but with the usual caveats about sampling errors and errors in judgment, it appeared safe to conclude that the production and marketing research of the agricultural experiment stations was not slanted toward the large farms. For example, production research represents nearly three-fourths of the

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experiment station effort. Of that production research directly related to some aspect of farming, nearly 78% was judged to be applicable to all sizes of farms; more than 10% was considered primarily useful to small farms, about 7% primarily useful to moderate-sized farms, and 5% applicable only to large farms. This is not to say that experiment station research is not making or has not made contributions to the changing structure of farming. The classification refers to the nature of the knowledge created, but it says nothing about the economic environment in which the knowledge is put to use. The task force adopted the treadmill and absorption or cannibalistic processes developed by Cochrane.

The task force concluded that even though the research effort may be characterized as producing knowledge applicable to all sizes of farms, the interaction of that knowledge with the economic environment results in a significant contribution by the experiment stations to a growing concentration of production on the larger-sized farms.

Whether the continuing trend toward concentration of production is perceived favorably or unfavorably will be decided in a larger arena than that of the American Agricultural Economics Association. But members of the profession do have a magnificent opportunity to help the public understand the issues involved by (*a*) making the current structure and changes in structure more understandable, (*b*) showing how tax and other policies designed for other purposes influence the concentration of agricultural production, and (*c*) investigating alternative ways of slowing down (or speeding up) the trend toward concentration.

The manner in which individuals and groups react to the concentration of agricultural production depends to a considerable extent on the relative weights they attach to different, sometimes overlapping, sometimes conflicting goals. Some widely held goals with respect to agricultural production are:

(*a*) Efficiency—an efficient agriculture producing an abundant food supply for domestic needs, reducing food shortages around the world and gaining foreign exchange earnings to purchase energy and other critical resources from abroad.

(*b*) Conservation—the availability of the quantity and quality of resources so that future generations can have an abundant food supply. This goal includes concerns about soil losses, farm land preservation, and depletion of energy resources.

(*c*) Employment opportunities—the availability of opportunities to work as a farm operator or laborer. This goal emphasizes the virtues of rural living, of "being your own boss," of the prospects of progressing from laborer to operator.

(*d*) Equity—the distribution of income within agriculture, and between farmers and nonfarmers. This goal expresses concern for low income consumers, for low income farmers, for reasonably equal returns for equal effort in alternative endeavors.

Individuals and groups who place a high relative weight on a particular goal may view the concentration of production quite differently from those who place a high relative weight on other goals. If agricultural economics research is to be useful in policy decisions regarding the concentration of agricultural production, it should illuminate the effects of alternative policy actions on these widely held goals.

Earlier studies of economies of size suggest that over a considerable range, size can be expanded at essentially constant costs. Farms larger than the minimum necessary to achieve those economies reduce employment opportunities (for potential farm operators as well as wage labor) with little offsetting gains to society in terms of lower food prices. A large variety of policies and programs intended for other purposes may encourage further expansion of size of farm beyond that necessary to gain efficiency and again reduce employment opportunities with little offsetting gains to society in terms of lower food prices. In a full employment economy, however, there may be gains from increased production of nonagricultural goods.

Changes in the structure of farming influence the structure of the assembly and processing system, and, conversely, changes in the market structure influence the access to markets of both inputs and outputs. The market access problem is further exaggerated to the extent that small farms produce different commodities than those to which the marketing system in the region is geared. Roadside markets, farmers markets and pick-your-own operations increase market access for a limited number of small- and moderate-sized farms. How can market access for small- and moderate-sized farms be improved?

Historically, changes in the concentration of

production on larger farms have influenced the nature of the rural community, i.e., decreased employment and wages in the local service sector. But in an era of vastly improved transportation and communication, it appears that changes in the structure of farming may also influence the development of the basic or "export" sector of the rural community. Agriculturists are fully aware that the nature of the rural community also influences the structure of farming in the surrounding area. Growth of the rural community not only converts agricultural land to residential uses, but also increases the possibilities for families to combine farm and nonfarm work in small and part-time farming operations.

This paper will not attempt to probe all the research opportunities associated with changes in the structure of farming. Instead it will concentrate on the study of economies of size in farming and on agriculture and community relationships.

Economies of Size

There are more reasons to study economies of size than to insure full employment for production economists. Many public policies are not specifically designed to change the structure of farming. Yet these policies may have indirect effects on that structure. If the indirect effects are conditioned by the economies gained by larger-sized farms, then we need to know the magnitude of these economies in order to gain some understanding of the indirect effects of such policies on the concentration of production.

For example, a price support program for corn in the first instance would increase the income of all corn producers in proportion to the amount of corn produced. If all incomes are increased proportionately there would be no initial effect on concentration. But if substantial economies of size exist, the higher absolute level of profits per unit of output, combined with the higher level of output for larger farms, will provide them both increased incentive and ability to further expand the size of farm.

Admittedly, the translation of that increased incentive and ability into actual increases in size of farms may be dependent on many factors such as tax policies, credit policies, the operator's willingness to assume risk, and the subjective evaluation of opportunity costs for the operator's family labor as well as the opportunity costs for equity in the business. Because many of these factors are themselves the subject of inquiry, e.g., tax policies, and others cannot be known by the analyst, analysis of the effects of various policies will continue to be of a budgeted or theoretical nature. But economies-of-size studies should provide essential building blocks for the conduct of such analyses.

Technical Economies

Many of the technical economies-of-size studies are outdated by reason of changes in technology as well as by reason of changes in prices paid and received. Studies of technical economies varied considerably in their definition of costs (Madden). At one end of the spectrum only cash costs are considered in the long-run average cost curve, and returns to land, labor, equity and management were treated as residual claimants; while at the other end of the spectrum, imputed costs were assigned to land, labor, equity, and management, with the risk-bearing factor the only residual claimant. The difficulties are twofold: (*a*) definition of costs may affect not only the level of the economies-of-size curve, but also the relative efficiency of small versus large farms, and (*b*) the interest in structure of farming suggests several alternative definitions of costs. For example, interest in the survival of small farms suggests the use of cash costs, particularly in areas where the availability of off-farm work is such as to provide the necessary family living expenses. Other interests, such as the size of farm necessary to provide returns to labor comparable to that in other industries, require the imputation of an opportunity cost on operator and family labor. Thus, we need not just a single economies-of-size curve for each type of farm, but rather a family of long-run cost curves reflecting different cost concepts (Miller, Rodewald, McElroy).

Miller, Rodewald, and McElroy, in a study of economies of size for field crop farms in seven regions, not only provide current estimates of economies of size, but also provide estimates of a family of cost curves representing different definitions of costs. Certainly the higher level of technology used combined with higher price levels have moved all long-run cost curves to the right, but the conclusion of the 1960s regarding a large range of nearly constant costs appears unchallenged.

While there was some variability in the shape and level of the economies-of-size curves among regions, a look at the average of cost curves for all regions may be useful. As size increased from \$59,000 to \$133,000 (an increase of 125% in sales), the cost per dollar of sales decreased 2.4¢, from 63¢ to 60.6¢. Thus, within this range the industry appears to approach a constant cost industry. Farmers in search of higher net farm incomes may wish to expand the size of their operation, but societal gains in terms of efficiency of production are minimal. The inclusion of an opportunity cost per operator and family labor at \$4.50 per hour, while increasing the level of cost, does not substantially alter the above conclusion.

There is also a need to estimate economies of size on livestock farms of various types as well as on mixed crop and livestock farms. Investigations of economies of size on these types of farms represent additional difficulties. Performance rates for labor in livestock production related to size of farms and technology uses are more difficult to come by, especially for the larger industrialized operations. Further, the methods used to estimate depreciation of buildings may have greater influence on the shape and level of the cost curves than in the case of crop farms.

Pecuniary Economies

Pecuniary economies or diseconomies are exemplified by volume discounts on the purchase of agricultural supplies and by volume premiums on the sale of agricultural outputs. But in some instances they may be regulated by federal or state governments. For example, small farms are exempted from unemployment insurance programs but larger farms must comply, representing a pecuniary diseconomy for larger farms. Other examples are environmental regulations as well as safety and health regulations. The literature on comprehensive studies of pecuniary economies and diseconomies is limited. Krause and Kyle surveyed forty-eight producers and a like number of input-output marketing farms to give some indication of major sources of economies and diseconomies on large corn farms in the Midwest. Purchasing seed, fertilizer, crop chemicals, and machinery, as well as output-marketing advantages were major sources of economies for large farms. In contrast, production labor was a significant diseconomy for larger farms. Presumably, this reflects a difference in the quality of labor. Larger farm units may very well require more experienced or more dependable labor to use sophisticated equipment. One way to reflect this in the LRAC curve is a pecuniary diseconomy. Special attention needs to be given to pecuniary economies and diseconomies because they may overshadow technical economies over a wide range of output. The difficult task will be to distinguish between pecuniary economies and bargaining power.

Tax Economies and Diseconomies

Dean and Carter, in a landmark study, have shown that progressive income taxes, when economic costs exceed deductible costs, reduce the optimal level of output. Because equity is usually greater than zero, the inclusion of an opportunity cost on equity, which is not deductible, reduces the optimal level of output. Likewise, they have shown that the higher the percentage of equity, the greater the imputed opportunity cost and the greater the reduction in optimal output. Thus, ignoring risk as a deterrent, expansion of the size of farm using borrowed capital was an attractive alternative. Using data from the Dean-Carter study, Carman has shown that increases in tax rates reduce optimal farm size and, conversely, that reduction in the rates increases optimal farm size. Thus the current debate in the Congress on tax reductions may have significant impacts on the concentration of agricultural production.

Dean and Carter also investigated the impact of taxes on the form of organization. Again, the approach was to show the after-tax economies of size for individual proprietorships and for family-owned corporations. Not surprisingly, the lower tax rates for corporations relative to the high tax rates for individuals in the higher income levels encouraged shifts to a corporate form of business organization on larger farms. Boehlje and Krause have also shown the advantages of incorporation from the perspective of growth in equity. Recent and prospective changes in the corporate tax rates are likely to increase the interest in incorporation, particularly among larger farms. But for now at least, the individual proprietorship remains the dominant form of organization.

Yet the real-world estimation of the effects of alternative tax provisions from that of other factors may not be possible. The imputation of

opportunity costs for operator and family labor and for operator capital is a subjective personal judgment not available to the analyst. Further, in inflationary periods it is the real opportunity cost of capital (not the nominal interest rate) which is relevant. Thus, the appropriate opportunity cost of capital is dependent upon the operator's expectations of future inflation rates relative to nominal rates. If real interest rates are expected to be quite low, then the imputation of opportunity costs for capital would be small and the reduction in the optimum size would be reduced. Thus, the effects of tax provisions on the concentration of production require data on operator judgments, motivations, and expectations—data which cannot be known by the analyst. Information on the effects of changes in tax policies will continue to be theoretical in nature. This may be humbling, but it should not detract from the utility to policy makers of information similar to that developed by Dean and Carter, or that using a simulation approach similar to that used by Eginton. In either case, the objectives are specific, e.g., maximizing growth in net worth or maximizing profit. Likewise, the assumptions regarding the real interest rates, the returns to operator and family labor, the technical input-output coefficients, the pecuniary economies and diseconomies are all specified. Thus, the factors deemed relevant by the analyst are clearly specified and all other factors are held constant, allowing the analyst to project the effects of alternative tax provisions on growth (Eginton) or optimal size of farm (Dean and Carter). One may question the realism of the assumptions, but the assumptions are clearly stated. The essence of the art is to choose a set of assumptions that are most likely to be considered realistic or to demonstrate the effects of alternative assumptions on the results.

Agriculture and the Community

Concerns about the concentration of agricultural production inevitably heighten concerns about the effects of concentration of production in the larger-sized farms on the well-being cern had an important bearing on passage of the Rural Development Act of 1972.

Goldschmidt had studied in 1944 two agriculturally dependent communities in California. Arvin was characterized as a large-farm community and Dinuba as a small-farm community. "The Study of Arvin and Dinuba shows that quality of social conditions is associated with scale of [farm] operations; that farm size is an important causal factor in the creation of such differences and that it is reasonable to believe that farm size is the most important cause of these differences" (Goldschmidt, p. 423).

The methodology used involved comparative case studies. The total agricultural production in the two communities was nearly identical. Very similar crops were grown, although Dinuba (the small-farm community) tended to specialize in fruit, while Arvin tended to specialize in vegetables and cotton. The two communities were located similarly with respect to highways, railroads, and cities.

The results of the study indicated that the small-farm community supported nearly twice as many business establishments, 61% higher retail trade and spent over three times as much as the large-farm community on household supplies and building equipment. Further, the small-farm community supported a larger number of people and the standard of living in the community was higher (better community facilities, more parks, more civic organizations, and more churches). Parenthetically, while the data from Dinuba and Arvin were not analyzed from the viewpoint of central place theory, there is some evidence (Goldschmidt, p. 386) to support the idea that Dinuba was a higher-order central place. If in fact Dinuba was a higher-order central place and it can be shown that the attractiveness of a community to the expansion of nonfarm export industries is related to its place in the hierarchy of communities, then some serious questions are raised about the Goldschmidt generalizations.

In the Goldschmidt study, the direction of causation is from large farms to reduced nonfarm employment and income without consideration of adjustment processes to the dis-

of the social condition (however measured) are far too complex to be attributed to a single factor such as farm size.

Heady and Sonka analyzed the effects of a number of farm-size alternatives on farm prices, net farm income, food costs, and nonfarm income generated in rural communities. They concluded that the small-farm alternative would indeed lead to greater income generation in rural communities and at a relatively modest cost to the consumer in terms of higher food costs. The income to operators of these small farms, however, would be at poverty levels. The methodology used involved a national linear programming model, a transportation sub model and an input-output sub model.

It seems self-evident that increases in the size of farm, accompanied by off-farm migration and by different shopping patterns of large-scale producers, will result initially in reduced employment opportunities, wages, and rents in the nonfarm local service sectors of some communities. The question arises, under what conditions is this a transitory or permanent condition? The answer to that question depends on changes in other basic (export) sectors in the community. From this initial condition, three alternative hypotheses are suggested: (*a*) lower wages, higher unemployment, and lower rents are insufficient to attract nonfarming basic industries into the community and people and businesses migrate to more urbanized areas resulting in a permanent depression of the level of economic activity in the rural community; (*b*) lower wages, higher unemployment, and lower rents are sufficiently attractive to nonfarming basic industries so that they migrate to rural communities, increasing employment, and causing wages and rents in the community to increase; and (*c*) lower wages and higher unemployment are insufficient to attract other industries into the community, but the aggregation of these conditions in the community and surrounding communities is sufficient to attract other basic industries to locate in one or more of the surrounding communities, so that they can draw on the excess labor supply of the overall area. The local communities which attract other industries are the beneficiaries of increased employment and income, while other communities become essentially bedroom communities with nonfarm employment limited to a few services. Certainly these appear to be relevant hypotheses, both from the standpoint of theory, and from casual observation of the equilibrating processes now taking place in rural areas.

The key to empirical testing of these hypothesized effects of farm size on rural communities is the definition of rural community. The definition is important from several viewpoints including: (*a*) the number of observations available for statistical analysis, (*b*) the availability of appropriate data sets, and (*c*) the delineation of community settings in which the alternative hypotheses might be operable. The latter is especially important because the expansion of an existing export or basic industry or the attraction of a new basic industry can be expected to be conditioned by the variety and level of services available in the community.

Historically, community studies have been more the purview of rural sociologists than agricultural economists. Sociologists think of a hierarchy of communities differentiated by the variety of institutions and social organizations. In this respect, the concepts of the rural sociologists and the agricultural economists (particularly those dealing with regional economics), appear to have some common ground. Central place theory describes the role of the central place (the variety and level of service industries) relative to the satellite places that surround it. Ignoring for the moment a hierarchy of central places, it is possible to generate some ideas about the testing of the alternative hypotheses suggested earlier. If we chose a satellite town and its hinterlands as our definition of community, then it would appear that the first alternative hypothesis of a permanently depressed level of economic activity in the community seems most likely. If, on the other hand, we choose the central place and its surrounding hinterlands as our definition of community, the second alternative appears to be a more likely candidate.

Next if we recognize the existence of a hierarchy of central places in rural areas, an index of rurality, then the third alternative (lower wages and higher unemployment are sufficient to attract other industries by the commuting process) appears to be a likely candidate.

High levels of aggregation over geographic space, e.g., state or multi-county regions, are not likely to allow the analyst to detect differences in employment changes attributable to differences in the hierarchical level of the central place. Further, definitions of community based on central place theory are not likely to

respect county lines. Federal data sets are largely county based, but state data sets in some instances provide information at a sub-county level. The Duns Market Indicator file does provide information at a sub-county level. Thus, these lower levels of aggregation based on a hierarchical scheme of central places can be expected to provide an adequate number of observations but at the expense of constraints on the data sets available for analysis.

Analyzing changes in the basic employment involves other decisions on the level of disaggregation. For example, some industries may locate near cheap labor (e.g., textiles), others may locate near intermediate inputs (e.g., food processing), and others may locate near important natural resources (e.g., steel). This implies that differences in the input mix are significant. Still other industries locate near markets. Statistical analysis, aggregating across all such industries, is likely to be inconclusive.

Further, since many of the inputs for a particular industry will come from some distance from the community, conceptualization of the supply of inputs must have a spatial component (e.g., the labor supply should include not only that labor available in the local region, but also that available from the surrounding areas). Further, a conceptualization of the supply of an input should reflect the demand of other users of that input. Likewise, conceptualizing the demand for outputs for a particular firm must reflect the supplies of the output produced by competing firms. Finally, the supply of particular inputs and the demand for specific outputs is unique to specific industries. All of this suggests that the analysis must be at a detailed level—disaggregated with respect to geographic space and with respect to industry.

An analysis of the effects on rural communities of a large-farm structure utilizing a concept of the degree of rurality and a more general framework (analyzing the kinds of industries likely to be attracted to different kinds of rural communities) will require a considerable commitment of resources. Thus, the question arises, does such an effort have real policy relevance, or is it only an example of intellectual nitpicking? The current administration has thus far been silent about rural development policy. Yet it appears that the concentration of production on larger farms will continue and the effects on rural communities will continue. It seems inevitable that this kind of research will again become high priority. In order to be ready with results when that time comes, the profession should make an investment in this kind of research activity.

No discussion of agriculture and the community would be complete without consideration of the effects of the community on agriculture—specifically the effects of growing communities on agriculture. Land use policy is the central issue. Yet the profession has not been able to suggest policies that meet the tests of effectiveness and economic and political feasibility. Perhaps we should turn our attention to investigation of incentive programs—incentives for businesses and residences to locate within the boundaries of small cities and towns rather than in the open countryside; and if they still choose to locate in the open country, incentives to locate on the less desirable agricultural land.

Summary

The continued trend toward concentration of production on larger-sized farms has many important implications for research by agricultural economists, only a few of which have been discussed in this paper. Emphasis was placed on studies of the economies of farm size, not only because the results facilitate the difficult choices between equity and efficiency, but also because they provide a vehicle for analyzing the effects of tax policies on farm size.

Emphasis also was placed on agriculture-community relationships, particularly those dealing with the influence of changes in the structure of farming on rural communities. There are reasons to believe that past studies, by concentrating on the effects on local service sectors, have overemphasized the depressing effects on the local economies. Further, the research proposed in this area would provide much useful knowledge for the guidance of national, state, and local development policies.

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U.S. Food and Agricultural Research Assessment: Implications for Agricultural Economists: Discussion

Joseph C. Purcell

This paper was based on an assessment of food and agricultural research focused on three key issues with regard to food and agricultural research: (*a*) management, (*b*) structure, and (*c*) priorities. The assessment was prompted by the perception that agricultural research is not well-managed, coordination and cooperation are poor, and there is not a clear understanding of the role of the participants in the system. Thus, the assessment was commissioned to (*a*) examine and elucidate the role of the participants in food and agricultural research, (*b*) develop more efficient priority-setting or allocation mechanisms, (*c*) clarify the role of both the federal and state governments in food and agricultural research support with respect to equity, and (*d*) develop a more efficient organization and management structure.

An assessment of the assessment should raise the issues of the justification for, and how well the assessment fulfilled, its objectives. Although expenditures for support of food and agricultural research are hardly discernible on a pie chart of federal expenditures, and that allocated to the economics of food even less discernible, the Congress should be concerned with the most effective use of every tax dollar including expenditures for congressional assessments. Two facts cast doubt on the justification of the assessment: (*a*) the food and agricultural sector is a model of efficiency and has improved consistently over time, and (*b*) federal support of research is extremely small and waning over time. A more valid justification for such an assessment should have been expressed in terms of a sustained high level of performance of the food and agriculture sector and the role of the federal support to assure a continued high level of performance, given the constraints on energy and other resources and a faltering economy. The balance of this discussion is directed to a few selected items.

Impact

The paper should convey to the U.S. Congress, and especially those with an urban orientation, that continuous and adequate funding of agricultural and food research and especially economic research is in the national interest, and the benefits flow predominantly to consumers. Food production is highly specialized and moves in interstate commerce and increasingly in international commerce. The equity issue clearly supports federal funding.

The paper failed to recognize the importance of competitive forces both in the agricultural-food sector and in the undergirding research. The U.S. economy has faltered in those areas where competitive forces are weak—e.g., autos and steel. A major role of the federal government is to establish and maintain a competitive economic environment, and it clearly follows that the public sector is responsible for research. While research in the private sector is privileged, publicly supported research is readily accessible to all potential users. Publicly supported research is more efficient in that unnecessary duplication can be minimized, and public research also fosters a competitive environment. This is equally true in the marketing sector as well as in farm production. The private sector's role is to use this flow of knowledge to develop patentable products and processes. This was not clearly elucidated in the paper.

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Evolution of the Agricultural-Food Sector

The evolutionary nature of the food-agricultural sector was not fully recognized in the Phillips-Dalrymple paper in terms of allocation of research funds with respect to value created, employment, etc. Initial emphasis of the research establishment was on self-sufficiency for each state. This was the way it should have been, as there was very little commerce in foodstuffs.

Specialization and large-scale production is an evolutionary process. Mechanical, chemical, and biological technologies contributed to the upward trend in efficiency of the food sector. What was not so well recognized was that a high degree of specialization required the simultaneous development of an efficient assembly, exchange, fabrication, and distribution system. In essence, about 80% of the economic (value-creating) activity associated with food is off-farm activity, and at least 50% of it is now in urban areas. Although the farm remains a vital link, the food system is no longer totally farm nor totally rural. Conversely, at least 80% of the traditional research program is still concerned with farm production activities. In dollars this is not too much, but other components are sadly neglected. The evolutionary nature of specialization and exchange requires an increasing emphasis on economic research. A viable food sector depends on efficiency in exchange and distribution and effective organization and management as well as technical efficiency. The necessity for simultaneous development in specialization in production and exchange and distribution was not fully recognized by research management nor by Congress.

Goals and Objectives

The paper alludes to the failure of the research establishment to identify clearly goals and objectives. The confusion surrounding goals may well be a failure to recognize that the agricultural-food sector is a component of the larger socioeconomic infrastructure. Thus, the implicit and directional goals of the greater society apply to all its components. Paramount among the greater societal goals is that of economic development, or rising affluence. Research directed to the efficiency of the agricultural food sector has made a major contribution to this goal and will continue to do so indefinitely. I do not concur that any absolute goal of affluence can be established. This and the short shrift of other societal goals is a major weakness of the paper. Reference to the "man-on-the-moon" and "auto mileage" as goals are purely transitory and mundane in character.

Economic and Other Social Research

The economics profession is to be faulted for failure to elucidate clearly the contributions of economic research to the food system. Organization and management are certainly vital to an efficient and viable food system. Inadequate organization and management are reflected in cycles and other evidence of over-under production contributing to inefficiencies and misallocation of resources, to name a few. However, in the research planning and budgeting processes, these kinds of constraints are seldom addressed. The low level of federal support for economic research related to food and agriculture was clearly elucidated in the Phillips-Dalrymple paper. However, the role of federal and state performers was rather muddled. There is no clear delineation of state and local problems as opposed to national and international problems. Also, the allegation that economists have never developed a process for problem identification simply does not jive with the record. For example, a framework for marketing research with clearly delineated problem areas in a matrix format has existed for eighteen years (Southern Marketing Research Committee).

Although the role of the public sector and the private sector in PHT and marketing research was a key issue in the OTA assessment, it was not adequately treated in the paper. It should be clearly recognized that the potential for resource conservation and cost reduction in the post-harvest sector is enormous. Food science has the potential to reduce land and energy requirements by 60%–70%, and adjustments in this direction are inevitable.

Conclusion

The OTA assessment of agricultural-food research generated a lot of verbiage. It was well-organized and conducted. However,

whether or not the assessment provided any real direction to the U.S. Congress and to research management with respect to funding, priority-setting, role of participants, unnecessary duplication, program balance, and other issues is debatable. Some good points were made, but the paper did not provide direction for the future. Less but well-directed verbiage would perhaps be more effective and productive.

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Research and the Family Farm: Implications for Agricultural Economics Research: Discussion

Eldon E. Weeks

Lee Day has done a courageous job, and as good a job as one can reasonably expect, in addressing this topic. The subject, inherently, is monstrously large; very ill-defined; and is a value-loaded, explicitly acknowledged cornerstone of U.S. farm policy. Day treated the subject wisely by addressing himself to a limited number of points—whether there is a slanting of experiment station research to the benefit of large farms, the economies of farm size, and agriculture and the community. Day said as much as could be said about these points within the constraints on the paper.

Because the discussant believes the above statements, this discussion will offer views of two additional dimensions that bear on both family farms and agricultural economics research. One of these dimensions consists of the consideration of basic definitional properties of family farms and a few of their implications for agricultural economic monitoring and research. The other is an expression of concern on my part over the apparent neglect, by economists, of activities involving the development and selection of advanced new biological/technological management systems in agriculture.

The Family Farm

According to the 1974 Census of Agriculture, 89.5% of all farms with sales of $2,500 or over were operated by individuals or families. These farms contain 74.9% of the land in farms with sales of $2,500 or over. Partnerships accounted for 8.6% of the farms and 13.7% of the land in farms. Thus, 98.1% of the farms, including 88.6% of the land in farms with sales of $2,500 or over, are operated by unincorporated farming institutions with proprietorships dominant.

The Standard Industrial Classification (SIC) Manual and the 1974 Census of Agriculture define farms as business establishments. With reference to the above data, agricultural enterprises are dominated by the operation of farms (business sector of the economy) by unincorporated households (households and institutions sector). Unless a farm is a single-establishment business enterprise operated by an incorporated operator, it is not a firm. This means that, in most instances, financial management, investment, and resource use decision making cannot be interpreted as self-contained functions within farm business establishments. Inputs are committed to farming operations, outputs accrue, and a residual of net factor earnings is available for transfer to the income accounts of farming institutions, 98.1% of whom are unincorporated operators. Of these, 69% receive income from off-farm sources.

The main impact of the above reduces to the proposition that, in the great majority of cases, the objectives guiding farm investments and activities are those of households rather than those of farm firms. Interpretation of the financial vitality of agricultural industry is directly dependent on the financial viability of the operator and his family, whose objectives related to farm investments and operations are members of a set of family objectives and aspirations. Thus, the size of current incomes from farm and off-farm sources may not be sufficient information to indicate financial status and progress, either of agriculture or of farm families, in terms of the combined perspectives of financial viability and well-being.

I wonder if it is not time to reexamine the

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The views expressed in this discussion are the author's and do not necessarily reflect those of the Cooperative State Research Service or the USDA.

kinds of definitional assumptions we make in modeling farming operations. And I wonder if we should again explore and identify relevant elements of the expected bottom lines motivating farm operator family behavior in relation to potential participation in such public policies as those concerned with farm production, resource conservation, environmental protection, food safety, etc. Also, I wonder if we cound not stand a catch-up effort in research on part-time farming, with emphasis on the economic behavior of part-time farm operator families. If we were to begin to delve into this subject, it is just possible we would discover that there is a lot we do not understand about that which we think we know.

Management Systems

It seems to me that there is an increasing tendency among agricultural scientists to adopt management systems orientations as frameworks for the design of biological/technological research and development programs. Examples of these are found in integrated pest management, integrated reproduction management, and several more related to crop and livestock systems management and other areas.

It would seem that economists and other behavioral scientists could be active participants in planning the design and delivery of research and development programs in these complex management systems areas for assurance that the bottom line objectives of family farm operators are considered. Often we see research program (project) goals stated, for example, in terms of such intermediate stages of impact as yield increase, just as if a number of other good things are bound to follow. We all suspect that circumstances of perspective and timing may affect the "goodness" of many of the things that might ultimately follow.

Even while the social and behavioral sciences are presently experiencing a belt-tightening era, it is possible that practitioners of research in these areas may find it fruitful to consider adding to their agendas some activities in needs assessments for research programs in the food and agricultural system. It may even be fair to propose that farm operator families in differing typical situations be considered among the major stakeholders in evaluating the research program alternatives.

Above all, it appears to me that farm operators are being asked to evaluate more and more increasingly complex technological and biological systems alternatives. One has to wonder how they can evaluate and integrate all the relevant practices that are urged upon them. Economic researchers could, again, commit serious attention to the evaluation of new biological/technological information and to the selection of management systems from the situational perspectives of farm operators.

Women in Agricultural Economics
(Sylvia Lane, University of California, Davis, Presiding)

The Conduct of the Survey on the Opportunities for and Status of Women in Agricultural Economics

Ardelle A. Lundeen and Annette L. Clauson

At its July 1980 meeting, the Executive Board of the American Agricultural Economics Association authorized formation of an ad hoc committee to investigate systematically the status, role, and opportunities for women in agricultural economics. A survey of females and males in the profession, including but not limited to members of AAEA, was undertaken. Because of the small number of women in agricultural economics (e.g., membership lists indicate that women comprise less than 5% of the AAEA), all women who could be identified in agricultural economics or related specialties were included in the survey. A sample of the much larger population of male economists was selected.

Questionnaire Development

The questionnaire was based on a similar design used by the Committee on the Status of Women in the Economics Profession (CSWEP) in 1974. Communications revealed that several items in the CSWEP 1974 survey were insignificant and therefore were left out of this survey. This survey was designed to make comparisons between male and female respondents, as well as to develop profiles in agricultural economics. The questionnaire was divided into five major parts.

Part 1 deals with the education and training of the respondents. This part covers when and why the respondents chose to become agricultural economists, as well as important positive role models that may have persuaded or dissuaded the respondents from entering the profession. Institutions attended, degrees received, and dates of degrees may be important when completing the profile of male and female respondents with respect to salary.

Part 2 covers work experience and career development of the respondents. Work history and no-work periods are key areas in part 2. The 1974 CSWEP survey indicated that wages, particularly the percentage of salary obtained from consulting fees, may show significant differences when profiling male and female respondents. Job mobility and types and numbers of publications are important areas dealt with in this part.

Part 3 covers the participation in the job market for agricultural economists since July 1979 and applies only to persons actively interviewing for jobs during that period. Questions on the type of prospective employer (university, business, or government) for each interview as well as the type of employer for a job accepted were included in this section. Comparisons of salary for jobs accepted, between male and female respondents and between types of prospective employers, are key areas of interest in this section. The number of interviews for each respondent is also a key item.

The effectiveness and problems of affirmative action during the hiring procedure are the emphasis of part 4. Possible problem areas dealt with in this section include female and male numbers in departments/divisions and in graduate programs, tenure, seniority, promotion, salary adjustments, and fringe benefits. Since the implementation of affirmative action, both males and females have indicated that they have encountered some problems in these areas.

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Part 5 deals with the personal background of the respondents. The specialties of the respondents may be significant when profiling male and female respondents. Family situation, including marital status, spouse's profession, number and age of children, is dealt with in this part.

The final questionnaire was designed to be administered to male and female agricultural economists, including graduate students; therefore only parts of the survey were completed by some respondents.

Sample Selection

Names of the female sample were obtained from several sources. The membership roster of the AAEA provided a starting point. Known women agricultural economists were asked to supply the names of other women in the profession. Women on the rosters of the Washington Women Economists (WWE) and CSWEP with relevant specialties also were included in the survey. A total of 540 persons made up the female sample (see table 1).

The male sample was selected from two sources. Each female respondent was asked to supply the name of a male of equal rank in her department or institution. To reduce bias in the selection process, the respondent was instructed to choose the male with the same rank or approximate level of job responsibility whose name appeared directly after (or before) hers in the alphabetical listing of agricultural economists at her institution or department. This matched-sampling procedure was intended to generate a group of males that would match as closely as possible the females under study.

Because only 84 names were obtained through the matched-sampling procedure, an additional 155 males were chosen randomly from the February 1981 list of paid-up AAEA members. The randomly chosen sample can be viewed to represent the male AAEA population more closely than the matched sample of male respondents. Identical questionnaires were sent to the females and males in the sample.

Table 1. Number in Sample and Response Rate for Surveys on Status of Women

Sample Group	No. in Sample	No. of Responses	Response Rate (%)
Female	540	159	29.4
Male	239	131	54.8
Matched	84	33	39
Random	155	98	63.2
Job search (both male & female)	233	122	52.4
Total	1,012	412	40.7

Early responses revealed that few persons had participated in the job market in the past two years and thus few persons had answered part 3 of the questionnaire, which involved job search activities. Since job search is an especially important component of the study, a separate questionnaire containing only part 3 of the original instrument, plus selected personal information, was developed and sent to persons who had accepted new positions within the past one and one-half years and to students nearing completion of degree work. Names of persons who had accepted new positions were obtained from AAEA newsletters from September 1979 to the present. Names of graduate students were obtained from rosters prepared by agricultural economics departments of universities and sent to prospective employers. Questionnaires were sent to 233 individuals in the job search sample.

Questionnaire Mailing and Response Rate

Questionnaires were mailed to approximately one-half of the female sample on 17 January 1981, with the remainder mailed a week later. Responses started to arrive in about two weeks.[1] The responses were generally slow in arriving, however, and after four weeks the response rate was only 21%. A reminder was sent to those who had not responded. Additional responses brought the return rate up to 29.4%. An additional 1.5% of the questionnaires were unusable because of incompleteness or wrong address. No further follow-up was undertaken for this group.

In view of the early indications of interest in the study by women and the fact that the results of the study have potentially important implications for them individually and more generally in the profession, the 29.4% re-

[1] The response rates and numbers cited in this paper reflect total responses in each category in each survey. Discrepancies between the numbers cited in this paper and the following three papers result from incomplete responses on some questionnaires and from different categories used by each analyst. For example, analysis may include all females, all males, matched sample of males and females, job search respondents, or some combination of these categories.

sponse rate is unexpectedly low. One possible explanation, however, is that women with specialties only peripheral to agricultural economics (e.g., Specialty Areas 420, 440, and 900–950) may not have identified closely with the profession.

The response to the 10 February 1981 mailing of the job search questionnaire was sufficient (a 52.4% rate) so that no follow-up mailings were made.

Questionnaires could not be sent to the male sample until the majority of female responses were received. Thus the mail questionnaires were not sent until 13 March 1981. Responses filtered in through 1 June 1981. One hundred and thirty-one responses were received, for a response rate of 54.8%. The response rate for the matched sample was 39% and for the random sample was 63.2%.

In this survey, as with most mail surveys, the possibility exists that the survey-respondents do not adequately represent the full range of members in the population. While the survey questions were factual, the objective of the project could have been viewed as controversial by some. A high response rate of individuals with strong pro or con feelings would be expected. For example, women who feel they have suffered discrimination and envisioned the study as a means to document this would likely have responded. On the other hand, females satisfied with their opportunities and/or who do not want to risk alienating male members of the profession may also have felt strong necessity to respond. Likewise, men who feel the study was anti-male or those particularly concerned with the status of women in the profession are more likely to have responded. Both males and females with neutral feelings, on the other hand, may have been less inclined to respond. While this raises the question of bias, time did not allow for the exploration of the possible nature of bias in the self-selection of respondents to the mailed questionnaires.

Coding and Analysis

The same coding structure was used for responses to all questionnaires to enable analysis not only by individual subgroups but for all subgroups combined. Selected personal information and job search activities were available from all 412 respondents. The remainder of the information from the longer questionnaire was available for 159 females and 131 males.

The male group was divided into two subgroups for analysis. Thirty-three of the male respondents comprised the matched-sample for comparison with their female counterparts. The remaining 98 male responses were from the randomly selected sample of AAEA members. This represents 2.97% of the total AAEA and may be used for analysis with the total female sample. The matched and random samples of males cannot be combined to provide a larger sample if either "matched" or "random" is a prerequisite. However, for some general characteristics, combining the two groups provides a larger sample for analysis.

Responses were coded and put on tape at South Dakota State University and sent to committee members for analysis of separate sections to be used in their respective papers.

A Comparison of the Rank and Salary of Male and Female Agricultural Economists

Linda K. Lee

The Committee on Opportunities for and Status of Women in Agricultural Economics was established by the Executive Board of the American Agricultural Economics Association in July 1980. The charge to the committee was "to ascertain the opportunities, role, and status of women in agricultural economics."[1] Two important determinants of status within the profession are rank and salary. The objectives of this paper are, first, to develop a profile of women within the agricultural economics profession. The distribution of female agricultural economists by type of job, level of education, and among academics, tenure status, is analyzed along with data on salaries, experience, and research productivity. Second, the relative rank of women within the profession is explored by comparing profile data of male and female AAEA members. Finally, a model is developed to determine if significant salary differentials exist between men and women of comparable rank. Conclusions about the current status of women in agricultural economics are presented.

A Profile of Female Agricultural Economists

Data for this analysis were obtained from a survey of men and women within the profession (Lundeen and Clauson). In an attempt to survey all female agricultural economists, 540 women with a possible interest in agricultural economics were contacted by the committee. Responses to the survey as of 1 July 1981 totaled 159 women, 89 of whom are members of the AAEA. Data in table 1 illustrate the distribution of women by type of job, level of education, and academic tenure status, where applicable. Mean salaries, average years since the last degree, and average number of publications per year are calculated for each category.

Of the 125 women who listed an identifiable current job, approximately 50% are academics, 30% are employed by government (state or federal), and the remainder are working for business and nonprofit corporations. The mean annual salary for all women surveyed is $20,589. Highest average salaries are reported by women with a Ph.D. employed by government. The lowest salaries are earned by non-Ph.D. academics without tenure, many of whom may be graduate students on assistantships. For all academics, the average annual salary of $17,659 is less than the average earnings of both government and business employees. It should be recognized that the inclusion of graduate students in the academic category may bias these salary comparisons.

The female survey respondents averaged just under six years since receiving their last degree. Overall, academics had more years of experience than government or business employees. The average number of journal articles and papers published per year was also calculated. All women surveyed averaged slightly less than one publication each year since their last degree was received.

Comparison of Male and Female Agricultural Economists

Questionnaires were sent to 239 males most of whom were randomly selected from the 1981 AAEA membership list (Lundeen and Clauson). One hundred thirty-one men responded by 1 July 1981. Because of the sampling frame used, most of the men surveyed

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[1] Letter from Luther Tweeten, President of the AAEA, to committee members, 2 September 1980.

Table 1. Distribution of Female Agricultural Economists by Selected Characteristics

Type of Job	Level of Education	Academic Tenure Status	Respondents[a]		Mean Salary	Average Years Since Last Degree	Average Number of Publications per Year
			(No.)	(%)	($)		
Academic	Ph.D.	Tenure	14	11.2	31,071	13.1	.8
		Tenure track	10	8.0	21,000	3.9	1.7
		Nontenure track	6	4.8	18,333	15.2	.4
		Not applicable	2	1.6	5,000	NR[b]	NR
	without Ph.D.	Tenure	1	.8	22,500	23.0	.4
		Tenure track	3	2.4	19,167	6.0	1.5
		Nontenure track	14	11.2	11,428	3.6	1.4
		Not applicable	12	9.6	7,083	2.4	.4
		No response	1	.8	22,500	5.0	4.8
Subtotal			63	50.4	17,659	6.8	.9
Government	Ph.D.		14	11.2	33,269	6.6	1.6
	Without Ph.D.		24	19.2	20,833	4.3	.6
Subtotal			38	30.4	25,203	5.3	1.0
Business	Ph.D.		6	4.8	26,667	4.8	.6
	without Ph.D.		18	14.4	19,265	4.2	.9
Subtotal			24	19.2	21,196	4.3	.8
Total			125	100.0	20,589	5.8	.9

[a] Information on type of job was not complete for 34 respondents. These data were not included in this table.
[b] NR = No Response

were AAEA members, while only 56% of women surveyed were association members. Although the differences between AAEA women and all women surveyed appear slight, to ensure comparable groups the responses were stratified for 104 male respondents and 72 female respondents with AAEA memberships.[2] These data are reported in table 2. Type of job, level of education, and academic tenure status were tabulated in addition to mean salaries, average years since last degree, and average number of publications per year for each job category.

Academics

Of the respondents with academic jobs, 55% of the men were tenured, compared to 24% of the women. A higher proportion of women than men did not have a Ph.D.: 51% of the women compared to 14% of the men. The "not applicable" response to questions about tenure status may indicate that many non-Ph.D. women are graduate students on assistantships. Apparently a higher proportion of female graduate students responded to our survey than did male graduate students, probably due to sampling techniques and interest in the survey.

Mean salaries for academic men are more than $14,000 higher than for their female counterparts, a trend that is observed in almost every tenure and educational category. Men also have more post-degree experience than do women—about five years more on the average. There is also a slight tendency for men to have more publications than women on a per year basis.

Government

Approximately 58% of the men in the sample and 48% of the female AAEA members in government have a Ph.D. Men with a Ph.D., however, have twice the experience as measured by years since the last degree and average almost $9,000 more per year in salary than women with a Ph.D. Among government employees without a doctoral degree, the experience and salary differentials are similar. Women in government appear to publish more than men, perhaps indicating an administrative role for more of the men.

[2] Twenty-seven men and seventeen women were deleted from the analysis because information on their current jobs was incomplete.

Business and Other

The largest disparities in salary and experience are found in the business and other category. Men averaged 13.7 years of experience and $38,667 per year compared to 2.3 years of experience and $17,292 in salary for AAEA women. However, there were relatively few respondents in this category. Women in business, as did women in government, reported more publications than men on a per year basis, perhaps indicating fewer administrative responsibilities than men.

Summary

A major difference in employment patterns between men and women is the smaller percentage of women employed in academic jobs. While 63% of male agricultural economists in our sample are employed by universities and colleges, 51% of female AAEA members have academic employment. Correspondingly, a higher proportion of women are employed in state and federal government than are men.

Mean salaries of AAEA women are lower than mean salaries of the men sampled. The average salary for the 104 men with an identifiable current job is $33,534 compared to a mean salary of $20,417 for the 72 women for whom data were available. Part of this differential may be explained by the years of experience accumulated by men and women. Men averaged 12.1 years since their last degree received; AAEA women as a group averaged 5.5 years of experience. In addition to less experience, women have a lower level of education than men. Approximately 57% of the women do not have a Ph.D. compared to 27% of the men. Both men and women average approximately one publication per year.

Factors Contributing to Salary Differentials between Male and Female Agricultural Economists

The descriptive data in tables 1 and 2 do not allow a comparison of the salaries of men and women with equivalent backgrounds. Although mean salaries for women are lower than mean salaries for men within each category, it is difficult to determine the role of experience, productivity, and other variables in producing this salary differential.

Accordingly, a model was developed to test

Table 2. Distribution of Male Agricultural Economists and Female AAEA Members by Selected Characteristics

Type of Job	Level of Education	Academic Tenure Status	Respondents[a] Men (No.)	Respondents[a] Men (%)	Respondents[a] Women (No.)	Respondents[a] Women (%)	Mean Salary Men ($)	Mean Salary Women ($)	Average Years since Last Degree Men	Average Years since Last Degree Women	Average Number of Publications per Year Men	Average Number of Publications per Year Women
Academic	Ph.D.	Tenure	34	32.7	8	11.1	38,309	32,812	16.0	13.5	1.2	.9
		Tenure track	16	15.4	7	9.7	29,000	21,071	4.7	4.0	3.1	1.9
		Nontenure track	5	4.8	3	4.2	25,000	14,167	8.5	2.0	.1	3.5
		Not applicable	1	1.0	0	0	55,000	0	21.0	0	.3	0
	without Ph.D.	Tenure	2	1.9	1	1.4	12,500	22,500	2.0	23.0	3.0	.4
		Tenure track	0	0	1	1.4	0	22,500	0	11.0	0	.6
		Nontenure track	5	4.8	9	12.5	14,000	9,722	7.0	3.4	.3	.3
		Not applicable	2	1.9	7	9.7	7,500	8,214	4.0	2.8	.1	.6
		No response	0	0	1	1.4	0	22,500	0	5.0	0	4.8
Subtotal			65	62.5	37	51.4	31,680	17,212	11.4	6.5	1.2	1.0
Government	Ph.D.		14	13.5	11	15.3	40,192	31,136	12.9	6.5	.7	1.4
	without Ph.D.		10	9.6	12	16.7	30,000	21,250	13.2	4.9	.4	.6
Subtotal			24	23.1	23	31.9	35,761	25,978	13.0	5.7	.6	1.1
Business and other	Ph.D.		6	5.8	2	2.8	38,750	28,750	9.5	1.5	.7	.3
	without Ph.D.		9	8.7	10	13.9	38,611	15,000	16.6	2.5	.1	1.3
Subtotal			15	14.4	12	16.7	38,667	17,292	13.7	2.3	.3	1.2
Total			104	100.0	72	100.0	33,534	20,417	12.1	5.5	.9	1.0

[a] Information on type of job was not complete for 27 male and 17 female respondents. These data were not included in this table.

for salary differentials between male and female agricultural economists after accounting for education, experience, research productivity, and other variables. The dependent variable in this model is before-tax 1980 salary or 1980 net business income, including consulting fees. Independent variables hypothesized to determine the salary of agricultural economists were:

(*a*) educational background—with Ph.D. = 1, otherwise = 0;

(*b*) research productivity—(i) number of journal articles and professional papers, (ii) number of books published;

(*c*) experience—(i) years since the last degree was received, (ii) tenure (months) in present job;

(*d*) administrative duties—administrator = 1, otherwise = 0;

(*e*) employer an academic institution—academic = 1, otherwise = 0;

(*f*) career interruptions—number of times unemployed for 6 months or more;

(*g*) consulting—percentage of income derived from consulting; and

(*h*) sex—female = 1, male = 0.

The regression results for the sample of men and women who are members of the AAEA are reported in table 3. After omitting incomplete responses, 145 observations were analyzed. The coefficients of the variables measuring publications and consulting proved insignificant. The coefficient for sex was significant, however, indicating mean salaries for women are $3,769 lower than for men, after controlling for the effects of other variables. This salary differential is considerably less than the $13,000 differential reported in table 2, indicating about $9,000 of that differential can be accounted for by variables other than sex.

Table 3. Regression Results for All Men and AAEA Women

Variable	Estimated Coefficient
Intercept	18,021.60
	(8.83)[a]
Ph.D.	9,528.07
	(6.17)
Books	3,901.38
	(1.85)
Publications	61.25
	(1.03)
Years since degree	379.42
	(3.94)
Tenure in job	103.01
	(4.38)
Administrator	6,693.20
	(3.07)
Academic	−5,681.62
	(3.95)
Career interruptions	−3,595.11
	(1.77)
Consulting	−365.71
	(.77)
Sex	−3,768.74
	(2.49)
F	30.70
R^2	.695
Number of observations	145

[a] Numbers in parentheses are *t*-values (absolute value).

It is possible that the significant salary differentials between men and women reported in table 3 relate to differences in job responsibilities not measured by the independent variables. As academics are a more homogenous group with respect to job descriptions than business or government agricultural economists, a separate regression equation was estimated to test for salary differentials between men and women in academia—the largest employer in the sample.[3] The results are reported in table 4. After omitting incomplete responses, 105 observations were available for analysis. The coefficients of books, career interruptions, and consulting proved insignificant. Again, after controlling for all other variables, academic women had a mean salary $3,038 lower than that of academic men. This suggests that although much of the salary differentials between academic men and women reported in table 2 are accounted for by explanatory variables other than sex, a significant salary differential between men and women in academia does exist.

Although mean salaries of men and women are significantly different after controlling for the independent variables in the model, it should be noted that there are other determinants of salary that are not accounted for in this analysis. For example, sex and regional location could be correlated in such a fashion as to bias the results, but this could not be determined in this study. Another important determinant of salary, quality of work, is not readily quantified and was not available from the survey data. Salary and advancement also can

[3] Because of the small sample size, all women academics, including non-AAEA members, were included in the model.

Table 4. Regression Results for Men and Women with Academic Employers

Variable	Estimated Coefficient
Intercept	10,104.57 (5.18)[a]
Ph.D.	12,445.83 (7.52)
Books	949.03 (.51)
Publications	113.79 (2.04)
Years since degree	438.09 (5.50)
Tenure in job	53.24 (2.31)
Administrator	6,554.53 (2.34)
Career interruptions	−1,789.78 (.99)
Consulting	889.46 (.97)
Sex	−3,037.93 (1.99)
F	34.54
R^2	.768
Number of observations	104

[a] Numbers in parentheses are *t*-values (absolute value).

be accelerated by interpersonal skills and rapport with colleagues and administrators, another unmeasurable factor. To isolate completely the effects of sex on salary, all of these factors should be considered.

The significant salary differentials between men and women reported in the models could result from a number of factors. If women in general are less mobile than men, have fewer job alternatives, and/or are less successful salary negotiators than men; salary differentials could result. Because the reasons for significant salary differentials are difficult to determine, it is interesting to note the responses of men and women in the sample on this topic. In response to the question, "Do you think you are paid less or have a lower level job than you would if you were the opposite sex?", approximately 4% of the men and 22% of the women said yes. A sizeable minority of women perceive salary differentials to exist and believe these differentials to be sex-related.

Summary and Conclusions

The survey data analyzed in this paper suggest that female agricultural economists have not yet achieved a rank within the profession equivalent to male agricultural economists. Lower levels of education, a lack of experience, and fewer women academics may be contributing factors. Furthermore, significant salary differentials between men and women exist after accounting for education, experience, research productivity, and other variables. These conclusions are consistent with reports of the rank and salary of women in science and with data on the rank of women economists in academia (Bayer and Astin, Bailey).

The real issue may be the future advancement of women within the profession rather than their current professional status. Although the number of women in the profession is currently small, one encouraging signal is the increasing numbers of female graduate students in agricultural economics. Between 1974 and 1979 the number of women enrolled as full-time graduate students in doctorate departments more than doubled—from 155 to 352. During the same time period, male enrollment increased by only 12% from 1,452 to 1,625 (Vetter and Babco).

These data indicate young women are optimistic about a professional future in agricultural economics. If that optimism is justified, the number of women in the profession should continue to increase. Improvements in the rank and status of these women, however, will depend upon advancement equal to that of their male counterparts.

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sponse was much less for female college faculty than for other sources of influence.

In the present survey, men almost always cited males as their most influential role models; most often cited were fathers and teachers. While women also cited fathers and teachers most often, more diversity existed in their responses. In particular, women listed female teachers more often than male teachers, and mothers appeared to exert significant influence. Women identified females as often as males as their most influential role models, while men almost never listed females.

Both sexes most often listed professors as the people who most encouraged a professional career; the greatest differences between male and female responses occurred for friends (more important for men) and professors and mothers (more important for women). Almost all men said that no one attempted to dissuade them from a professional career; while the majority of women concurred, women also reported a variety of dissuasive influences.

Academic Background

While men were more likely than women to rank in the upper 25% of their college graduating class, women were more likely to rank in the upper 2%. Men were somewhat more likely to have had statistics and advanced mathematics courses as undergraduates, but women were more likely to have taken calculus, economic principles, and advanced (general) economics. Men were more likely to have been agricultural economics majors as undergraduates, although, like women, many men also turned to graduate agricultural economics from other undergraduate majors. In general, then, women have had more background in general economics than men, while men's academic background has been more agriculturally oriented.

Contrary to what the literature on women's career paths indicates, women Ph.D. recipients were about as likely as men to have interrupted their Ph.D. study. This again may be partly because women agricultural economists are more likely than men to have never married and never to have had children (or at least to begin having children after the highest academic degree was completed); thus, home responsibilities of women and men may be roughly comparable. However, when women did interrupt their Ph.D. study, it was more likely to delay the dissertation and for more extended periods of time. Surprisingly, men were more likely than women to delay the dissertation because of home responsibilities, and women more likely to delay in order to gain job experience. Although women were less likely to receive assistantships and during Ph.D. coursework provided their own financial support somewhat more often, during the dissertation period they were more likely to rely on fellowship support and less likely to rely on working their way through. During both phases, women were less likely than men to receive aid from relatives as a major source of financial support.

Also contrary to popular opinion, women agricultural economists were more willing to move more than 100 miles to a job which offered higher pay than were men. The increased likelihood that female agricultural economists have never married may contribute to this result. Because for the majority of married couples, the man's career still takes priority, one would expect at best an equalization of mobility of men with predominantly single women. However, women were more likely than men to have moved in the past because of family preferences.

Both sexes were more likely to concentrate on agriculture and natural resources as primary professional specialties; of these, women were about evenly divided between agriculture and natural resources. However, women more frequently than men listed consumer economics as their primary specialty (nine of the thirteen 900-classifications were in 920, consumer economics) and less frequently listed economic growth and development and business.

Factors Which Affect Completion of a Ph.D. Degree

Based on the factors discussed above, a logit model was constructed and estimated to explain the decisions of women and men to pursue and complete a Ph.D. degree (table 2). First, the later in school the person made the choice of field, the more immediate the possibility of getting the Ph.D. and the more likely that it would be undertaken and completed. Second, the primary reasons for choice of field were considered; perhaps if one chose the field because of personal interest in it, one would continue as far as possible in its study; while if one chose it because of economic opportunity,

Table 2. Logit Determinants of Ph.D. Completion

	Women		Men	
Variable	Coeff.	χ^{2a}	Coeff.	χ^{2a}
Intercept	−0.5763	0.22	1.8385	1.01
Time of career decision	0.6920	6.14	0.6449	2.83
Chose field because of interest	−0.4013	0.65	−1.0235	1.90
Chose field for economic gain	−0.3495	0.24	−0.1703	0.05
Father most encouraging	−1.7280	3.00	1.4594	2.23
Mother most encouraging	−1.0028	1.03		
Teacher most encouraging	−1.5074	3.89	1.5426	4.10
No one encouraged career	−1.9495	3.96	0.1836	0.04
No one discouraged career	0.2834	0.30	−2.0508	3.00
Academic rank in college	−0.1678	0.96	−0.7697	5.17
Never married	−0.9180	3.80	−3.7444	10.41
Percent correctly predicted	67.7%		77.2%	
Predictive accuracy coefficient	0.137		0.345	

[a] Chi-square statistics for assessing significance of individual coefficients (Nerlove and Press, p. 45).

one could find sufficient opportunity at the bachelor's or master's levels. The encouraging influences of father, mother, and teacher were discussed previously; also included in the model were the lack of any encouragement and the lack of any discouragement. Those of highest academic ability were hypothesized to be more likely to complete the Ph.D.; those never married were presumed to have been more free to concentrate on graduate study.

As expected, men and women responded differently to these factors; however, not all of the predicted effects held at the 10% level of significance. Most unexpected was the negative effect of never-married status. It appears that for both sexes, the married individuals are more likely to complete the Ph.D. For both sexes, the later in life the decision was made to enter agricultural economics, the more likely the Ph.D. completion. No effect of reasons for choice appeared for either sex. College academic rank (1 = highest, 5 = lowest) was a significant factor for men but not for women. Men and women responded oppositely to most encouraging (and discouraging) influences. Men responded favorably to encouragement from fathers and teachers, although they apparently needed some challenge against which to respond as seen from the negative effect of lack of discouragement. Mother's influence could not be analyzed for men because very few men listed mothers as the people who most encouraged their careers. Either women responded negatively to encouragement from fathers and teachers (and surprisingly, not at all to mothers) or, more likely, the professional careers women were encouraged to undertake did not require a Ph.D. The model explained Ph.D. completion better for men than for women.

Conclusions

Women agricultural economists do differ from their male counterparts primarily in family situation and professional motivation. They are more likely to have never married, or at the least to have completed academic preparation before turning to child-rearing. When married, they are more likely to have married men of equal or higher educational background and income, and to possess a Ph.D. degree, but yet at the same time they appear to have largely resolved problems of career mobility. They are likely to be older than the males, on the whole (partly because of greater numbers of returning women students), and to have been more greatly influenced by female role models. Although they tend to have had a more general-economics-oriented academic background than the men, they presently specialize to no lesser extent in agriculture and natural resources. In keeping with the academic stereotype, however, they do choose human-oriented specialties more often than business-oriented specialties, while for men the reverse is true. The distinctive career motivation among women agricultural economists is intellectual interest, as compared with greater emphasis by men on market considerations. It will be interesting to see if these

patterns continue over time as women's participation in agricultural economics increases and whether the character of agricultural economics research output changes as a result.

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Evidence on Barriers to the Parallel Advancement of Male and Female Agricultural Economists

Sylvia Lane

Barriers to parallel advancement of male and female economists and managers (but not agricultural economists) have been studied in some detail (Reagan, Strober, Epstein, Gordon and Strober). Reagan wrote, "On the supply side, barriers to full career development for women are likely to be those common to all professional occupations plus the effect of women's perceptions of the intensity of the demand-side barriers of the particular profession (i.e., any lack of support of male colleagues, professional isolation and lack of access to information network, or employers' lack of perception of the women's career potential). One group of supply-side barriers includes presence of children, husband's unfavorable attitudes, guilt feelings of women related to a high sense of responsibility for monitoring consumption at home, and poor earlier education choices based on limited perception of career possibilities. In addition, the two probably most important barriers are geographic mobility or immobility, related to demands of family, and lack of the on-the-job training caused by either gaps in the women's career patterns or diminished opportunities for investment in human capital for women who are working" (Reagan, p. 100).

Gordon and Strober emphasized "recruitment, hiring and promotion policies" (p. 158) (demand-side barriers common to all professional occupations), and Sutherland found women had lower professional aspirations (supply side) (pp. 774, 794).

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The three highest barriers to career development cited by women with doctorates studied by Astin were "getting adequate domestic help" (supply side), "employer discrimination" (demand side) and "husband's mobility" (supply side) (p. 150).

Epstein lists (*a*) the American image of the female role and its concomitant attitudes and behavior which are often inappropriate in the professional world (which when internalized is a supply-side barrier); (*b*) simply enjoying one's work often not being perceived as an adequate justification for a woman working; (*c*) the lesser parental investment in education for young women in many cases because it has a lower present value; (*d*) the lack of role models for professional women; (*e*) societal expectations concerning appropriate occupations for women and pressure on women to think in terms of contingency careers instead of careers as their prime occupational objective; and (*f*) the tendency of women to choose typically female professions (Epstein, chaps. 1, 2). The listed categories are all supply-side barriers. They are not all mutually exclusive, and the list is not all-inclusive.

Irrespective of the factors involved, the lack of parallel advancement in occupational categories similar to that of agricultural economists has been documented. Reagan found a $2,400 difference in pay between the "typical" Ph.D. woman economist and her male counterpart seven years after the woman economist received her Ph.D. (p. 101). Johnson and Stafford, studying female academics, found "(1) beginning salaries for females are not substantially less than for male academics; and (2) the rate at which salaries increase with years since the Ph.D. . . . is much greater for male than for female academics" (p. 203). After twelve years of potential experience, women in their sample earned 23% less than the men (p. 203). Salaries of

female academics are averred to decline relative to those of male academics with years since receipt of the Ph.D. up to age 45 (p. 205). The important hypotheses explaining the differentials were both the division of labor/acquired skill hypothesis (women drop out of the labor force, primarily to raise children more often than men and do not acquire as much on-the-job training) and discrimination (pp. 216–17).

Human capital theorists posit time out of the labor market reduces the accrued human capital stock because of a gap in the process of appreciation and because of capital depreciation. Discontinuities were found to be greater for married than for single women (Mincer and Polachek). Huttner found the number of breaks in paid employment rather than time away from paid work to be inversely associated with earning levels, and Jusenius suggested women in high-skill occupations suffered the highest penalties (Kalsare, p. 663).

Reagan, from her analysis of the data from the 1974–75 survey of economists, suggested that the discrepancy between salaries for equivalent male and female economists was due to women accepting lower wages than men if their geographic mobility was restricted because of their husband's employment or if they wanted to work close to home because of children.

In this analysis, the hypotheses to be tested, stated in the null form, were that (*a*) attitudes, human capital, and mobility did not result in salary differences between female and male agricultural economists holding equivalent positions, and (*b*) barriers to parallel advancement were not falling and therefore salary differences for male and female agricultural economists holding equivalent positions, controlling for years out of school, should be the same for younger and for older women.

Methodology

Data used was from the Survey of Women in Agricultural Economics conducted in 1981 (Lundeen). First, frequencies were compiled for the occurrences of the barriers studied for a sample of 282 women in the surveyed population for whom there were complete records. One hundred eighty-four, designated as "younger women," had completed the requirements for their highest degree in 1971 or thereafter. Ninety-eight, designated "older women," were awarded their highest degree prior to 1971. Second, data for 21 pairs of "matched" male and female agricultural economists were used in a multiple regression analysis to explain salary differences. In all, there were 33 "matched" pairs in the data set, i.e., pairs of male and female economists working for the same firm or institution. Women had designated the man in the same department and/or position with equal rank whose name appeared next to their names alphabetically on the department list or employment roster. However, data needed for the analysis was incomplete for 12 of the pairs and, therefore, they were excluded from the regression analysis.

The model estimated was

$$D = f(A_s, A_d, C, M),$$

where D is the difference in salary between a woman who is an agricultural economist and a man in the equivalent position divided by the years since each received her/his highest degree, A_s is attitudes that have their effect on the supply of women who are agricultural economists, A_d is attitudes that have their effect on the demand for women who are agricultural economists, C is differences in human capital, and M is differences in mobility. A_s, in the estimated equation, was a series of eight variables. They were:

(*a*) if people tried to dissuade female respondents from pursuing a professional career;

(*b*) the need to devote a large amount of time to administer consumption;

(*c*) spouse's negative attitude toward the female agricultural economist's working;

(*d*) relatives' negative attitudes toward the female agricultural economist's working;

(*e*) lack of appropriate role models;

(*f*) social or professional isolation on the job;

(*g*) the number of times the respondent left a job she liked and moved because her spouse or another family member needed to live in another area; and

(*h*) other barriers which included (in their own words) lack of direction in college, lack of support from faculty when a student, inadequate financial support during graduate work, personal reluctance to call self economist and work with them, nonacceptance of women in field, lack of worthwhile work in field, inability to fit into system in place of work, no mentor, no referral/buddy system for women, work in

a chauvinistic company, difficulty about learning about available options, colleagues' sexist attitudes, personal obligations, nationality/cultural obstacles, and "political repression." This is not a complete list.

A_d in the estimated equation was a series of three variables:

(*a*) employers' lack of perception of female respondents' professional potentialities;

(*b*) employers' expressing a preference for hiring a male rather than a female agricultural economist; and

(*c*) questions related to the spouse and/or domestic situation appearing to be a disproportionately important consideration in the minds of potential employers.

Data used for the variable pertaining to less investment in human capital, *C*, was compiled from the number of six-month gaps in the work history of the women who responded in the survey.

To gather data concerning mobility, *M*, a question was included in the questionnaire asking if the respondent was willing to move to a better-paying, more responsible position 100 or more miles from her/his present location within the next two years.

These, except for family moves which were correlated with the number of six-month gaps, were the independent variables in the final regressions, which were estimated using ordinary least squares.

There probably are simultaneities and interactions among the independent variables. For younger women there were positive correlation coefficients over .6 for problems with consumption management and the number of six-month gaps in the work history. This was also true for the spouse's negative attitude and the reporting of having encountered other barriers. This could well be due partially to a psychological interaction.

Findings

As indicated in table 1, 53.5% of the 282 women who responded to this question indicated they had been dissuaded from pursuing their professional careers. Of the female agricultural economists responding 53.2% found the need to devote a large amount of time to administer consumption to be a problem. Her spouse's negative attitude toward her working was a problem for 52.8% of the respondents. Relatives' negative attitudes were a problem for 53.2% of the respondents. The lack of role models was a problem for 53.9%; isolation on the job for 52.8%; family related moves for 8.9%, and other barriers for 14.2%.

As for the demand-side barriers, 54.3% of the women reported the employer's lack of perception of their potentialities to be a problem; 20.9% reported their employers preferred to hire male economists, and 95.7% reported having been asked a disproportionate number of questions related to spouse and/or domestic situations during interviews, and that such questions appeared to be important considerations in the mind of potential employers.

Eleven percent reported there had been gaps in their work history and 32.3% reported they were willing to move more than 100 miles within the next two years to a job with higher pay and greater responsibility.

That over half were dissuaded was perhaps not unexpected. That consumption management was a problem for over half was also not surprising.

The fact that the female economists' domestic situations appeared an important consideration in the mind of potential employers according to over 95% of the women reporting is revealing. The almost one-third of the female economists reporting who are willing to move within the next two years to a job 100 miles or more away from their present job if it had more responsibility and higher pay was a higher proportion than expected.

Among the 130 male economists who responded to this same question, 39.2% reported they were willing to move. There was a statistically significant difference between male and female agricultural economists in this regard. The males were more mobile.

Actually, being married, in itself, constitutes a barrier interrelated with consumption management, gaps in work history, and spouse's negative attitude. Of the 62 women surveyed who reported consumption management to be a problem, 72.6% were married. Of the 55 women who reported they were single (never married) 78% reported consumption management was not a problem, as opposed to 40% of the 75 women reporting being currently married. Married women also had more gaps in their work history. None of the women who were not currently married (separated, divorced, or never married) reported having more than three gaps, but 10% of the 75 married women did. Forty-four percent of the married women had gaps in their work history as opposed to 33% of the single women.

Table 1. Evidence of Barriers to Parallel Advancement of Male and Female Agricultural Economists

	Percentage of Younger Women Reporting (N = 184[a])	Percentage of Older Women Reporting (N = 98[a])	Percentage of Total Sample Reporting (N = 282[a])
Supply-Side Barriers			
Dissuasion	50.5	59.2	53.5
	(3.7)[b]	(5.0)	(3.8)
Consumption management	49.5	60.2	53.2
	(23.0)	(23.5)	(17.1)
Spouse's attitude	49.5	59.2	52.8
	(26.4)	(30.1)	(20.1)
Relatives' attitudes	49.5	60.2	53.2
	(18.6)	(22.8)	(14.5)
Lack of role models	50.5	60.2	53.9
	(11.5)	(21.4)	(10.7)
Isolation on job	49.5	59.2	52.8
	(11.0)	(19.7)	(9.9)
Family-related moves	7.6	11.2	8.9
	(3.1)	(5.0)	(2.6)
Other barriers	12.0	18.4	14.2
	(4.0)	(7.5)	(3.7)
Demand-side barriers			
Employers' lack of perception	51.[illegible]	60.2	54.3
	(12.6)	(21.1)	(11.0)
Employers' preferences for male economists	23.9	15.3	20.9
	(3.2)	(3.7)	(2.4)
Employers' interest in family affairs	96.7	93.9	95.7
	(1.3)	(2.4)	(1.2)
Human capital			
Gaps in work history	7.6	17.3	11.0
	(2.2)	(5.3)	(2.4)
Mobility			
Willingness to move to job with more responsibility[c]	32.6	31.6	32.3
	(3.5)	(4.7)	(2.8)

[a] Percentage of women surveyed reporting this as a problem.
[b] Standard errors in parentheses.
[c] Only variable compared to males; difference between males and females significantly different above 95% level.

When comparisons were made between the women who had completed work for their highest degree ten years or more before the survey and those who had completed the work for their highest degree within the last ten years, some interesting differences became apparent (table 1). A higher percentage of the older women had encountered all of the listed supply-side barriers. The differences between the younger and older women were all statistically significant.

As to the demand-side barriers a higher proportion of older women reported their employers lacked perception of their potential. A lower percentage of older women reported their employers preferred hiring male economists or had a disproportionate interest in their family affairs. Older women had more gaps in their work histories, as expected. They had more time to accumulate them. The older women were somewhat less willing to move than the younger women, and that, too, was expected. This was also true of older versus younger men. Every one of the differences in the recorded percentages for the demand-side barriers between the older and younger women was statistically significant.

The mean difference in salary per year since they had acquired their highest degrees between the younger women in the sample and their male counterparts (for the 11 cases in the matched pairs) was $311.60 per year. The female economists earned less. The mean difference in salary per year since the acquisition of the highest degree for the older women in the matched pairs and their male counterparts was $59.38. The women earned more. The difference between the younger and older women

was statistically significant at the 95% level. For the 21 matched pairs, the mean difference per year was $134.94, with the men earning more.

The independent variables that were statistically significant in explaining the salary discrepancy for the 21 women in the matched-pair regression equation were (table 2) the spouse's negative attitude toward the female economist's working (at the 90% level); relatives' negative attitudes (at the 90% level); lack of role models; the employer's lack of perception of the female agricultural economist's potential; the employer's undue interest in family affairs during the female economist's interview; and the number of gaps in the female agricultural economist's work history (the latter four all being significant at the 95% level or above).

Table 2. Regression Coefficients for Independent Variables for Women in the Matched Sample

	B-Coefficient Total Women Matched Sample[a] (N = 21)
Supply-Side Barriers	
Dissuasion	−1510.8 (.677)
Consumption management	−1131.8 (.895)
Spouse's attitude	4745.5[c] (2.08)
Relatives' attitudes	−2997.7[c] (2.07)
Lack of role models	2796.7[b] (2.78)
Isolation on job	−467.3 (.504)
Other barriers	712.9 (.516)
Demand-side barriers	
Employers' lack of perception	2193.9[b] (2.1)
Employers' preferences for male economists	−243.5 (.23)
Employers' interest in family affairs	−1948.2[b] (2.20)
Human capital	
Gap in work history	4878.9[b] (2.55)
Mobility	
Willingness to move to job with more responsibility[b]	1051.2 (1.12)
R^2 = .76	

[a] T-test statistic in parentheses; all T-tests not valid for older and younger women subsamples because of the small size of the samples.
[b] Significant at 95% level and above.
[c] Significant at 90% level.

Summary and Conclusions

The women questioned, who returned questionnaires in the 1981 survey of agricultural economists, had, for the most part, been dissuaded from becoming agricultural economists, found they had problems with consumption management, had spouses with negative attitudes toward their working, had relatives with negative attitudes toward their working, lacked role models, found they were professionally or socially isolated on the job, felt that they had employers who lacked perception of their potential, and had been questioned excessively about family affairs during interviews. Both the supply-side barriers and the demand-side barriers existed for a majority of these women. For the younger women, they undoubtedly contributed to the salary discrepancy between the women and their male counterparts, even though the younger women had fewer gaps in their work history. In the case of the older women, the discrepancy was positive. Those in the sample of "matched pairs" earned more than their male counterparts. But the sample was very small (there were 11 "younger" and 10 "older" women).

Statistically significantly higher percentages of older women encountered each of the supply-side barriers, leading to the conclusion that these barriers may no longer be as pervasive as they were. Concomitantly, statistically higher percentages of older women reported their employers lacked a proper perception of their potential, implying more employers may be perceiving female agricultural economists' potentials for achievement similarly to the economists' own perceptions (recognizing their capabilities). A statistically significantly lower percentage of older women, however, reported their employers preferred hiring male economists, which may indicate their employers' lack of bias when they were first hired or that they have proven women can be capable agricultural economists. The fact that the percentage for this barrier is as low as it is overall, (20.9%) is encouraging. The high percentage of the women surveyed who reported employers having an undue interest in family affairs during interviews (and this was statistically significantly higher for the younger women)

indicates women have yet to be treated equally with men during the interview process.

The statistically significantly higher percentage of older women reporting gaps in their work history probably reflects the milieu during the period of their careers. Many were working during the 1950s when the accepted norm for a woman was to be primarily home-centered, and this norm was then a more formidable supply-side barrier than it has been during the last 20 years (Korbin). That this percentage is as low as it is (17.3%) for older women and considerably lower for younger women (7.6%) indicates female agricultural economists tend to have strong career commitments. The fact that 32.3% of the women surveyed reported they were willing to move to a position paying more, with more responsibility, over 100 miles away from their present location dispels the notion that female agricultural economists are far less mobile than male agricultural economists. There is a statistically significant difference between the two (39.2% of the men were willing to move) but the difference is not that appreciable. Not surprisingly, the younger agricultural economists were more mobile than the older ones. And single women, who had fewer problems with consumption management, fewer gaps in their work history, and no spouses with negative attitudes toward their working, were more mobile.

Of the variables that were significant in the regression, three were supply-side variables: the spouse's negative attitude toward the female agricultural economist's working, relatives' negative attitudes, and the lack of role models. Two were demand-side variables: the employer's lack of perception of the female agricultural economist's potential and the employer's undue interest in family affairs during female economist's interviews (indicative of the employer's thinking). One, the number of gaps in the female agricultural economist's work history, would suggest a lesser acquisition of human capital, which would tend to result in salary levels lower than they might otherwise be.

The two significant variables that were unexpectedly associated with less, rather than more, discrepancy in salaries were relatives' negative attitudes and the employer's asking an undue number of questions about family affairs during the interview. The first may simply not be very important to the women. The second may be rational on the part of the employer assessing the commitment of younger women, but it is discriminatory and illegal. Its apparently not resulting in a greater salary discrepancy is an interesting finding.

The evidence, although in the case of the regression results it is only suggestive because of the small size of the sample, indicates that attitudes of both the males and the females and the difference in human capital do result in differences in salaries per year since completion of the requirements for the highest degree. The main impact of these factors is on younger female agricultural economists. Married female agricultural economists have more barriers to advancement than single female agricultural economists. But barriers are falling. Fewer younger female agricultural economists report encountering the "barrier indicators" considered in this analysis. Finis Welch's thesis may be correct. Each cohort in a minority group tends to encounter fewer barriers than the one preceding it, but it would seem the older women in the matched sample of female and male agricultural economists advanced faster than the males despite the barriers. The positive discrepancy for the older women could be accounted for by the presumption that Zoloth suggested: the older women had to be outstanding to overcome the higher barriers they faced. Kushman suggested they may have benefited from their scarcity in light of affirmative action pressures and their proven track records. In conclusion, there appear to be different supply and demand curves not only for male and female agricultural economists but for younger and older women among the female agricultural economists.

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Abstracts

Symposia

Perceptions, Attitudes, and Risk: Overlooked Variables in Formulating Public Policy on Soil Conservation and Water Quality. Lee A. Christensen, presiding (ERS/University of Georgia), Peter Nowak (Iowa State University), Webb Smathers (University of Georgia), John Miranowski (Iowa State University), and Pierre Crosson (Resources for the Future), David Ervin (University of Missouri), and Wesley Musser (University of Georgia).

Nowak contrasted the traditionally held belief that wealthier farmers are more risk-prone and therefore more likely to adopt innovations with Cancian's thesis that the lower income groups are more receptive to adoption in the early stages of the diffusion process. He found Cancian's thesis to hold in the adoption of reduced-tillage systems. The risk-taking orientation associated with the early adoption of an innovation usually associated with higher income groups is diminished by uncertainty and limited information.

Miranowski discussed the inadequacies of budget analyses and linear programming models in representing the decision-making processes of farmers. These techniques generally ignore risk attitudes and human capital characteristics. Iowa farmers' perceptions of the yield impacts of various tillage technologies were found to be consistent with research evidence, but there is great variation in their risk attitudes.

Smathers addressed the disparity between actual and perceived attitudes of farmers toward conservation and water quality practices. Conventional wisdom holds that there is a weak private incentive to invest in soil conservation and water quality improvement practices. However, Georgia farmers were found willing to adopt technologies and management systems which would reduce input use and risk.

Crosson addressed the divergent interests of farmers and society on soil conservation and water quality. Farmers will not be nearly as sensitive to the off-farm damages of erosion as the public. Thus, where these damages exist there is a clear case for public intervention to reduce the damages. The argument for societal intervention for preservation of soil productivity is less convincing.

Issues in U.S./Soviet Bloc Agricultural Trade in the Eighties. James Jones, presiding (University of Idaho); David Schoonover (FAS USDA); Bob Jones (Purdue University); Steven Schmidt (University of Illinois); Dennis Conley (University of Illinois); and Robbin Johnson (Cargill).

Discussants in the symposium reported on research dealing with various facets of U.S./Soviet bloc grain-marketing arrangements and trade relations under auspices of the NC-139 regional research project.

Prospects of Soviet agricultural import requirements in the 1980s were surveyed. It was observed that the Soviets likely will remain an important buyer of U.S. grain products for the foreseeable future. The bilateral grain agreement between the United States and the Soviets was appraised in terms of its historical performance. Its value in facilitating acquisition of information from the Soviets of their import intentions was noted. Possible firm-level strategies of dealing with Soviet bloc purchasers through countertrade, technical assistance, and other arrangements were raised. How successfully the Soviet bloc economies deal with their shortages of foreign exchange, and the course that political relations take with the West were noted to be overriding considerations in shaping agricultural trade prospects.

Economic Statistics for Agriculture: Current Directions, Changes, and Concerns. Richard Perrin, presiding (North Carolina State University), William Kibler (SRS USDA), Shirley Kalleck (Bureau of the Census), Gaylord Worden and John Berry (Office of Federal Statistical Policy and Standards), Glenn Nelson (University of Minnesota), Bruce Gardner (University of Maryland), and James Bonnen (Michigan State University).

Kibler reported on the current probability survey approach used by SRS, including a description of sampling frames and sampling procedures for crop and livestock reports, and he described changes in the offing. Kalleck discussed the changes in enumeration procedures between the 1974 and 1978 agriculture censuses and listed some changes to be made in the 1982 census. She then discussed census concerns for the future, especially the difficulties in describing farm structure changes as farm-nonfarm linkages continue to change. Berry and Worden described sources of pressure on census and USDA statistical operations, including federal budget restrictions and mandated reductions in respondent burden, and urged the profession to organize so as to influence the changes that will occur.

Nelson reviewed in some detail the changes in statistics made since the Price Spread Task Force report and concluded that the report was used in a constructive manner and that it had a significant impact. Gardner reviewed recommendations of the Task Force on Economic Indicators and concluded that ERS had responded wisely, but went on to list remaining problems in the accuracy of some series and the meaning of some others.

Bonnen pointed out several factors which have increased the value of economic statistics (deregu-

lation, formula funding, farmer information systems) and urged the Economic Statistics Committee to attempt a careful description of remaining data problems. The papers prepared for this symposium will be duplicated and made available through the organizers.

Survey of Annual Outlook Information: 1981. John Ferris, presiding (Michigan State University), Gene Futrell (Iowa State University), George Hoffman (ESS USDA), Everett Nichols (North Carolina State University), Leonard Haverkamp (Wilson and Company), James Cornelius (Oregon State University), and Dean Chen (Wharton EFA).

The symposium was organized around the results of the fourth annual survey of AAEA members' forecasts of selected agricultural and economic data. A general summary of the 1981 survey results was presented by Gene Futrell. As with previous surveys, there did not appear to be any consistent forecast differences associated with the respondents' institutional affiliation, degree of outlook responsibility, or the extent to which formal forecasting models were used. Hoffman presented the detailed survey results on forecasts of general economic and general agricultural data and expressed his view on the likely values for the various data. Similarly, survey results and comments on crops were presented by Nichols and on livestock and poultry by Haverkamp. This was followed by general discussion.

Cornelius presented an analysis of the results of the three previous AAEA surveys of annual outlook information. Forecasting performance was evaluated for slaughter cattle, feeder cattle, hogs, corn, soybeans, and wheat. Near-term forecasts (for the current year) have been more accurate than far-term forecasts (for the following year). Forecast accuracy has also varied among commodities. Chen discussed the sources of forecasting errors and procedures for decomposition of forecast error. He suggested that more consideration be given to the identification and measurement of the reasons for error in outlook forecasts.

New Dimensions in Teaching Agribusiness Management, Farm Management, and Agricultural Policy. Duane G. Harris, presiding (Iowa State University), William D. Dobson (University of Wisconsin), Carl L. Pherson (California State University-Fresno), and R. G. F. Spitze (University of Illinois).

This symposium discussed future challenges in teaching courses in agricultural economics and agricultural business. Brief presentations were made by Dobson on agribusiness management, Pherson on farm management, and Spitze on agricultural policy. Then the audience divided into separate discussion groups for each of the subject matter areas, to share teaching ideas.

Dobson emphasized that good teaching in agribusiness management is highly labor intensive. Effective use of case studies can greatly enhance student learning, but such exercises require a substantial commitment of faculty time, especially as class sizes continue to increase.

Pherson suggested that future challenges in teaching farm management include meeting a growing need for developing student expertise in the areas of labor management, credit management, tax management, and government regulation. He also argued that risk management and intergenerational transfers of farm ownership and control need more attention.

Spitze stressed that three overall strategy issues arise in the teaching of agricultural and food policy—serving various levels of student academic maturity, selecting the subject matter content of our instruction, and developing an effective approach to teaching policy.

Modeling Agriculture in the 1980s. Marvin Duncan, presiding (Federal Reserve Bank of Kansas City); Dean W. Hughes (Federal Reserve Bank of Kansas City); John B. Penson, Jr. (Texas A&M University); and Hovav Talpaz (Texas A&M University).

This symposium examined three modeling efforts and the manner in which general economic and agricultural sector data are incorporated into these models. Womack's paper reports on the design and application of a sector econometric model that incorporates supply and demand interaction among agricultural commodities. Particular attention is devoted to incorporation of relevant international economic data into the model.

The Hughes-Penson paper outlines a general equilibrium model (GEM) and its application in valueing the incorporation of agriculture in a macroeconomic model. GEM captures the following important linkages with agriculture: producer-input supplier, farm output-retail food demand, balance of trade-exchange rates, government sector, and credit markets.

The Talpaz-Penson paper addresses the design and application of general equilibrium optimization models emphasizing agriculture. The models discussed utilize a quadratic input-output methodology, which relies on welfare economic theory, and are particularly useful for national and regional policy analysis.

The Implications for U.S. Agricultural Trade of Enlargement of the European Community and Future Developments in the Common Agricultural Policy. Stephen Magiera and John Dunmore, presiding (ERS USDA); Tim Josling (Stanford University); Gene Hasha, David Kelch, and Tham Truong (ERS USDA); Harold Riley (Michigan State University); Robert Thompson (Purdue University); and Alexander Sarris (University of California, Berkeley).

The newest EC enlargement must be viewed within

the context of the Community's current budgetary crisis. The common agricultural policy (CAP) is seriously threatened by the expense of mounting agricultural surpluses. Rather than a radical restructuring of the CAP, one is likely to see price restraint or restrictions on the quantities qualifying for CAP support, particularly milk products and cereals. The accession of important producers of Mediterranean products will exacerbate some of the CAP's problems and influence its evolution. Competition and budgetary problems will be heightened, particularly when Spanish and Greek olive oil come under the CAP.

The ability of the new countries to take full advantage of CAP regulations and aid depends on a number of factors—one of which is the formation of producer groups. In Spain, these groups are few in number and poorly organized in comparison to their EC counterparts.

EC tariff reductions on new members' fruits and vegetable exports will lead to a sizeable expansion of their sales to the EC. However, the enlargement impact will be small compared to overall trends in world trade. U.S. cotton exports could expand because of the abolition of Greek and Spanish tariffs and because of the greater restrictions imposed on EC textile imports negotiated under the new multifiber arrangement.

Enlargement could have a substantial impact on livestock production and feed demand in the new members. Corn and sorghum deficits, although continuing, will increase at a much slower pace. U.S. soybean exports will continue to expand because of the elimination of Spanish soybean tariffs.

Agricultural Transportation in Transition: Issues and Policy. Forrest Stegelin, presiding (University of Florida); Ken Casavant (Washington State University); Marc Johnson (North Carolina State University); Lowell Hill (University of Illinois at Champaign-Urbana); and Stephen Fuller (Texas A&M University).

The role of transportation is to facilitate agriculture and the consumer, not to reinvent the wheel. Agricultural transportation is characterized as an intermediate service (a total derived demand), playing a sensitive role in establishing the quality of competition among both firms and regions, and a geopolitical phenomenon (not just economic) having an enormous proportion of overhead in total cost. Traditional issues include the competition (or lack thereof) between modes, the stability and performance of exempt carriers, short-haul versus long-haul performance, and the cost economies associated with existing managerial expertise. Relatively new issues include the costs and availability of energy, truck weight and length restrictions, rail car shortages, intermodal arrangements, backhauls, highway user fees (cost responsibility by size), waterway user charges, locks and dams, seasonal rates, storage and export facilities, managerial opportunity costs and imperfect knowledge, and reregulation. Welfare theory and the recovery of public investment, potential regulation (inconvenience versus inefficiency), and deregulation are the likely issues and policies forthcoming in agricultural transportation.

Microcomputer Applications: Hardware, Software Documentation Professional Reward, and States' Activities. James M. McGrann, presiding (Texas A&M University), Gordon A. Rowe (University of California), Steven C. Griffin (Texas A&M University), and Ernest Bentley (Virginia Polytechnic Institute and State University).

This symposium discussed microcomputer hardware, operating system and language trends, program documentation and software evaluation, and professional evaluation and recognition for computer software development. Individual state activities were presented by participants.

Noncompatibility of microcomputer hardware, operating systems, and languages is a problem facing microcomputer users. Rowe stated that the CP/M operating system is increasingly accepted as an industry standard. Standards have been developed for the S-100 bus microcomputer systems but not for integrated systems like TRS-80, Pet, or Apple. Structured features for new versions of BASIC and standards to discourage incompatibilities to protect competitive positions of manufacturers can be expected.

Griffin discussed the problem of lack of user manuals and documentation of microcomputer software. Minimum requirements were specified for documentation and manuals. A check list is presented to facilitate software selection and evaluation for farmers and ranchers.

Bentley noted that agricultural economists have a new media to disseminate their research and educational programs through microcomputer software. Means to provide evaluation and peer review of software must be found to gain recognition by administrators for the professional activity in development of software. Bentley suggests a journal of agriculture software be developed.

Development and Application of Cooperative Theory and Measurement of Cooperative Performance. Randall E. Torgerson, presiding (ACS USDA), George Ladd (Iowa State University), Jeffrey Royer (ACS USDA), John Van Sickle (University of Florida), and Mahlon Lang (Purdue University).

Papers presented on cooperative theory were original approaches based on cooperative objectives. Ladd surveys past theoretical and empirical work in the context of cooperatives' objective functions and synthesizes one that recognizes both the interests of members on the farm and in the cooperative. In so doing, he advocates the use of mathematics to carry out informative institutional economics. In a

means-end hierarchy of goals, Ladd argues that a cooperative's highest-level objective is maximization of members' net revenue, or more precisely, maximization of present value of members' net revenue.

Royer presented a model for the short-run production and pricing decisions of cooperative associations. The model was compared graphically to earlier works by Phillips and by Helmberger and Hoos.

Van Sickle reviewed cooperatives' treatment under the various tax laws and presented a model of the financial structure of cooperative associations. This model essentially adopts that presented by Royer in developing a theory of cooperative financial structure.

Lang summarized results of comparative performance studies of cooperatives and noncooperative firms. The study found that cooperatives provide more marketwide and producer services than do noncooperative firms. They also provide farmers with a greater sense of control over their destinies and more market security. Aside from these factors, no dramatic difference in the performance of cooperatives and noncooperative firms were reported.

Economic Modeling Inputs to Pesticide Regulatory Decisions: Comparison of Alternative Models. Arnold L. Aspelin (Office of Pesticide Programs, U.S. Environmental Protection Agency) and Earl R. Swanson, presiding (University of Illinois), Klaus F. Alt (ESS USDA), Fred T. Arnold (Data Resources, Inc.), Glenn S. Collins (Texas A&M University), Dennis C. Cory (University of Arizona), Lewis Daugherty (University of Arizona), Earl O. Heady (Iowa State University), Wen-yuan Huang (ESS USDA), Roger A. Selley (University of Arizona), C. Robert Taylor (Montana State University), Sue Webb (Iowa State University), Edward Weiler (Office of Pesticide Programs, U.S. Environmental Protection Agency), and Thomas Yost (administrative law judge, U.S. Environmental Protection Agency).

Several months prior to the symposium, four different modelling groups were asked to estimate the economic impact of cancelling the registration of a hypothetical pesticide used on soybeans in twenty-five states. Results from four models were presented: (*a*) AGSIM, a regionalized econometric-simulation model developed by Collins and Taylor, (*b*) the NRED-CARD Hybrid model developed at Iowa State University, (*c*) the DRI (Data Resources, Inc.) econometric model of U.S. agriculture and the DRI macromodel of the U.S. economy, and (*d*) a simplified supply/demand model developed at the University of Arizona. Each of the four estimates of total average annual impact was divided into its impact on consumers and on producers. Although the estimates of total impact from three of the four analyses were remarkably similar, there were substantial differences among models in the allocation of the impacts between consumers and producers. In his comments on the results, Yost emphasized the importance of using basic economic logic and removing economic jargon from reports to be used as testimony in the regulatory process.

Industry, Government, and Academic Perspectives on Research Priorities in Agricultural Marketing. Clement E. Ward, presiding (Oklahoma State University), Timothy M. Hammonds (Food Marketing Institute), Allan B. Paul (ERS USDA), Richard G. Heifner (AMS USDA), and J. Bruce Bullock (Oklahoma State University).

Performance of the food-marketing system is being increasingly questioned. Symposium participants discussed the adequacy of agricultural marketing research in answering these questions.

Agricultural economists have become quantitative historians and are not addressing fundamental economic issues. Industry economists believe the *Journal* contributes to the image that agricultural economics research is irrelevant to the business community. Research focusing on increased productivity in the food distribution system is needed.

Government economists are faced with a broad array of problems. Research needs include intangible marketing functions. For example, research is needed on the proper role of government, e.g., cost-benefit analyses of government services and institutions and the optimal level of government to maintain competition.

Much of the agricultural marketing literature suggests our food-marketing system is inefficient. Relevant questions are whether a feasible alternative industry structure could provide more net consumer welfare without increasing resource use. More attention is needed conceptualizing how markets behave in a dynamic, uncertain environment.

Agricultural Economics in China. R. J. Hildreth, presiding (Farm Foundation), Reed Hertford (Ford Foundation), Peter Calkins (Iowa State University), Larry Connor (Michigan State University), Delane Welsch (University of Minnesota).

Agricultural economics in China is undergoing a rebirth. All teaching and research in agricultural economics ceased in China during the cultural revolution. In 1976, China's new leadership revived the profession to foster more effective management of agriculture.

The demand for agricultural economists appears large, relative to supply. The Agricultural Economics Society has a membership of about 1,000, which may also be a good estimate of the number of senior economists.

Plans call for doubling undergraduate enrollment by 1985 from the 2,600 now enrolled. Several agricultural colleges and universities have been desig-

nated key point schools and have priority in teaching staff, teaching materials, and students. Probably no more than 50 agricultural economists are presently receiving graduate education in China.

Possible AAEA activities to help reinvigorate agricultural economics in China, perhaps through a special committee, include: back-stop assistance for the Chinese Agricultural Economics Society; invite the Chinese to review AAEA's activities; make the exchanges between the U.S. and China in agricultural economics flow both directions; and provide publications to help rebuild agricultural economics libraries.

Embargoes Evaluated. Gary L. Seevers, presiding (Goldman, Sachs & Co.), Ted Rice (Continental Grain Company), Tim Josling (Stanford University), and Dale Hathaway (Consultants International).
The panel reviewed the consequences of four "embargoes": 1973, 1974, 1975, and 1980. The first three were based on actual or perceived short-supply situations; the fourth on political grounds. The first applied to all countries; the last three were directed primarily at the USSR.

Josling provided a classification system. The four embargoes would fall in at least three different categories.

Although each embargo has been unique, all share the following attributes: (*a*) Embargoes are disruptive and add uncertainty to all parties. (*b*) While the immediate result has been to depress U.S. grain prices, the impact on volume of world grain trade has been minimal because grain is fungible. (*c*) Longer-term adverse consequences may have been exaggerated, but one has been greater reluctance by importers to become overly dependent on the United States for supplies.

Most discussion was about the USSR embargo announced 8 January 1980. Hathaway said decisions to invoke embargoes have been taken without regard to or without examination of technical analysis of either their effectiveness or their domestic and international consequences. In brief, embargoes have been made for political rather than economic reasons.

Embargoes were considered undesirable. Ways to avoid short-supply embargoes were suggested. Nevertheless, panelists agree that embargoes were likely to occur again.

United States Agricultural Transformation and the State: Alternative Perspectives on Emerging Contradictions and the Continuing Crisis. Christopher Feise, presiding (King County, Washington, Cooperative Extension), David Holland (Washington State University), Phillip LeVeen (Public Interest Economics, West), Darrel McCleod (University of California, Berkeley), and Margaret Andrews (Rutgers University).
Three overlapping subject areas were given attention: (*a*) the role of the state and the problems it faces as it attempts to resolve the contradictions associated with the current stage of advanced capitalism; (*b*) interrelations between agricultural export policy, food price inflation, wages, and changes in real output; (*c*) the dynamics of agricultural structural change and the implications for changing class and political locations in the rural population.

One basic theme was that the "market-(export) oriented" approach to food policy, while fulfilling the promise of expanded markets and increased exchange earnings, has simultaneously resulted in the development of greatly increased food price instability. The role of food price changes in affecting industrial sector wages, industrial profits, rates of industrial productivity growth, and monetary and fiscal policy was discussed.

An additional major topic was the changing class location of the agricultural population emphasizing the implications for political alignment. It was argued that the main feature of U.S. agricultural structural change has been the decomposition of independent commodity production (family farming) into one of three major categories: wage laborer, part-time farmer, or capitalist farmer.

The social base for populist politics in rural areas is disappearing as capitalist farming increasingly dominates agriculture. Part-time farming, while occupying a contradictory class location, appears to be obscuring the contradictions of agricultural structural change.

Extension Programs That Work: Some Real World Examples. Gerald Campbell, presiding (University of Wisconsin, Madison), Richard Barrows (University of Wisconsin, Madison), Gerald Doeksen, and James Nelson (Oklahoma State University).
Barrows discussed his public policy education program on rural land use policy. He employed a variety of educational methodologies and materials in the different stages of problem identification, discussion of policy options, state and local government choice, and program implementation and review. His clientele included farmers, farm and environmental organizations, the Wisconsin State Senate and Assembly, the Wisconsin Department of Agriculture Trade and Consumer Protection, and other state agencies. Barrows and his students developed a research base on farmland preservation programs, and he worked closely with legislative enactment of the Farmland Preservation Program. Barrows was on part-time leave as the initial administrator of the program.

Doeksen and Nelson emphasized the importance of direct contact with clientele groups in problem identification. They emphasized that their 25% research appointments allowed them to generate the bulk of the needed research. Doeksen and Nelson reported on programs in community service, economic development impacts, and taxes. Primary

clientele groups were local governing boards and operations personnel for towns, counties, and special districts. Their program has produced well over 100 local community reports.

Local Government Service Provision in Nonmetropolitan Areas. Brady J. Deaton, presiding (Virginia Polytechnic Institute and State University), Paul Gessaman (University of Nebraska), Judith N. Collins (EDD ESS USDA), and Paul W. Barkley (Washington State University).
Each emphasized the need for rural communities to be understood as institutions by both researchers and decision makers. Gessaman charged that the profession has not sustained its commitment to community services research. He presented a model for minimizing the conceptual difficulties of output measurement and borrowed concepts from activity analysis to guide researchers.

Collins related trends in local government finances to changes in income, population, and debt of various size communities. Rural governments depend more heavily than urban areas on local property taxes and user charges. "Revenue effort" has recently declined in metropolitan areas and to an even greater extent in rural counties adjacent to SMSAs.

Barkley stressed the inherent conflicts among the concepts of efficiency, equity, and institutional reform as applied to community services. Attempts to base policy on these concepts may run counter to policies designed to promote a sense of "community" based on small-scale, geographic restrictions and local control.

The New Agricultural and Food Policy—Status Report. Robert G. F. Spitze, presiding (University of Illinois), Hazen F. Gale (U.S. Department of Treasury), Kenneth C. Clayton (ERS USDA), Wayne A. Boutwell (Staff Economist, Senator Cochrane), Harold D. Guither (University of Illinois), and Daryll E. Ray (Oklahoma State University).
New public agricultural and food policy is being developed to succeed the terminating Food and Agriculture Act of 1977. This follows the evolutionary path of price and income policy initiated in 1929. The new policy will be important to producers, consumers, traders, agribusinesses, and rural communities. This symposium provided an opportunity for agricultural economists to hear from policy workers close to the decision making but from different vantage points, about the issues, participants, and likely directions.

Gale stressed the high priority given to budgetary considerations in all policy decisions. Clayton concurred and expanded the theme about how the new budget process and "budgeteer" staffs had shifted the dialogue from program content to costs, perhaps to occur annually. Boutwell recounted similarities with past congressional hearings, counselled agricultural economists to be more active in policy, and identified problems for research.

Guither summarized the views of a sample of farmers in ten states, finding their preferences generally expressed in the new policy. Ray's evaluation of the primary future policy problems included finding instability issues becoming more intense and structural issues becoming dormant.

How Can the International Committee of AAEA Expand Its Service to the Agricultural Economics Profession? Darrell F. Fienup, presiding (Michigan State University), Arthur J. Coutu (North Carolina State University), James P. Houck (University of Minnesota), and Morris D. Whitaker (BIFAD and Utah State University).
The basic concern of this symposium focused on ways and means by which the AAEA International Committee can help strengthen the capabilities of the agricultural economics profession in development work. There is particular need to increase the participation of young U.S. professionals in international development research and training activities in both the U.S. and abroad.

One proposal would create a new discipline-oriented institutional structure that might be organized by the AAEA International Committee to serve as a contracting, granting, and implementing agency for international training, research, and overseas technical assistance. Projected benefits would derive from a more focused approach to development issues and more effective utilization of talents available. Constraints include long-term funding for a core budget and potential conflicts with existing institutions that employ internationally oriented agricultural economists.

The International Committee, as presently organized, should give greater support to communication and interaction among younger U.S. and LDC professionals. Seminars and workshops, like those sponsored under ADC/RTN, were considered an important activity for professional interaction. The need for more research opportunities in development, especially small grants for Ph.D. thesis research, was emphasized. Communication about existing sources of funds needs improvement. Establishment of better linkages with the International Research Centers, BIFAD, AID, ISEC, etc., should help to promote shared objectives as well as improve international opportunities for AAEA members.

Socioeconomic Factors Affecting Rural Land Use. Gerald Cole, presiding (University of Delaware), Greg White (University of Maine), Dale Colyer (West Virginia University), Bruce Lindsay (University of New Hampshire), and Nelson Bills (USDA ESS).
Discussion centered around the sampling procedure, methodology, and hypotheses tested for a survey of over 1,600 rural landowners in nine

Northeast states in 1979 and 1980. The central hypothesis of the study was that attitudes and views of growing numbers of nonfarm rural residents can significantly affect land-use policies and decisions.

White discussed sampling procedure and survey design. The sample was based on population growth and density by county in the northeastern states for the period 1970–76. The questionnaire was designed to obtain a socioeconomic profile of the owner/user, basic information about land ownership and use, and gathered responses on a range of attitudinal variables.

Colyer described the owner characteristics and reasons for owning land. Lindsay briefly summarized the empirical results of the study and related the results to existing land-use regulations in the northeastern states. Owners who do not expect land-use changes in the next five years represent the highest proportion in support of land-use regulations.

Bills compared the USDA national land-use survey results with those obtained in the Northeast and noted a high degree of similarity between the two studies for the Northeast region.

Selected Papers

Irrigation Policy and Practice (Harry Ayer, NRED ESS USDA/University of Arizona, presiding)

"Irrigation Scheduling in the Oklahoma Panhandle Using Stochastic Dominance Theory." (Thomas R. Harris and Harry P. Mapp, Jr., Oklahoma State University)
Irrigated production in the Oklahoma Panhandle has increased significantly during the past three decades. However, the source of groundwater is declining and the cost of fuel is increasing. Proposed irrigation technologies which use less water and fuel are evaluated by stochastic dominance analysis for possible adoption by irrigated producers.

"Economic Impacts from Regulating Groundwater Use." Dorothy A. Comer (University of Florida) and Raymond J. Supalla (University of Nebraska)
Groundwater mining has become a critical issue in several areas. This study uses a recursive linear program linked directly to a hydrologic model to evaluate how groundwater use regulations would impact on farm income in Nebraska. Findings indicate that it is possible to significantly extend aquifer life, without substantially reducing farm income at either the firm or the regional level.

"Optimal Groundwater Mining in the Ogallala Aquifer: Estimation of Economic Loss and Excessive Depletion Due to Commonality." Kun C. Lee, Cameron Short, Earl O. Heady (Iowa State University)
The optimal rates of intertemporal and within-group groundwater mining in the Ogallala Aquifer are estimated for the year 1985 to 2005. Economic losses and excessive depletion due to commonality and economic life of the aquifer are measured under alternative levels of energy and crop prices.

"Motivating Adoption of Best Management Practices: Implications for Cost Effectiveness." Donald G. Killingsworth and Scott C. Matulich (Washington State University)
The traditional cost effectiveness framework was broadened to incorporate some key motivations underlying the adoption of erosion control practices in irrigated agriculture. Selected financial factors were found to be important determinants of adoption. Failure to incorporate such factors promotes overestimation of cost effectiveness, improper ranking of BMPs, and ultimately faulty policy prescriptions.

Modelling (Larry Salathe, NWS ESS USDA, presiding)

"Modeling and Testing for Jointness in Agricultural Production." C. Richard Shumway and Rulon D. Pope (Texas A&M University), and Elizabeth K. Nash (University of California, Berkeley)
Allocatable fixed factors, e.g., land, must be added to the traditionally regarded causes of jointness in agriculture. Their presence also necessitates multiple-product systems for modeling product supply and factor demand. In other important ways, however, their analytical implications are very different from other causes of jointness.

"Use of Stochastic Simulation to Value Improved Crop Forecast Information." Duane L. Marquis (FAS USDA) and Daryll E. Ray (Oklahoma State University)
Consumer and producer surplus is used with the National Agricultural Policy Simulator (POLYSIM) to estimate the value of improved crop forecast information. For the three supply-demand scenarios evaluated—excess, tight, and fluctuating—the net domestic value of improved information is positive ($512 and $73 million) for the latter two situations.

"Tatonnement Modelling: A Variation to Linear Programming." Burton C. English, Cameron Short, and Earl O. Heady (Iowa State University)
An iterative solution incorporating demand equations and on national interregional linear programming model is explored. Conditions for stability are found and comparison of an iterative solution process and a fixed demand solution is made. The iterative process used in the analysis allows the model to adjust demand levels when the supply curve shifts as a result of increased production costs.

"Agricultural Price Expectations: An Erroneous, but Better, Approach to Measurement." Robert D. Weaver (Pennsylvania State University)
The subjective, market-level expectation of price is an unobservable which at best can be measured with error. The usefulness of the past and current cash prices and futures prices are considered. An errors-in-variables model of price expectations is introduced and applied in a model of U.S. aggregate soybean supply.

"Demand, Supply, and Price of Hardwood Lumber." William G. Luppold (U.S. Forest Service) and Joseph Havlicek, Jr. (Virginia Polytechnic Institute and State University)

A cobweb model with causal flow originating from the demand relationship is used to analyze the effects of exogenous variables on quantity and price of hardwood lumber. Wage rate, interest rates, stumpage price, lumber exports, and price of lumber demanders' output were the major factors influencing quantity and price.

Grain Policy (Edward W. Tyrchniewicz, University of Manitoba, presiding)

"Modeling Acreage Response in a Controlled but Uncertain Market." Robert G. Chambers (University of Maryland) and Richard E. Just (University of California, Berkeley)
A method is developed for modeling acreage response subject to acreage quotas is developed and applied to the case of wheat. The model assumes expected utility maximization and empirical analysis is based on the indirect expected utility function and limited dependent variable analysis.

"An Economic Analysis of the Effects of Commodity Program Options on the Financial Position of Representative Indiana Crop Farms." Mark A. Edelman, Marshall A. Martin, and Timothy G. Baker (Purdue University)
Financial positions of four Indiana crop farms were analyzed with an annualized LP model. Commodity programs that distribute payments based on the volume of production did not differentially influence income, net worth, and risk exposure across farm size. Furthermore, program options had less impact on farm growth than firm-level investment decisions.

"Less U.S. Government Intervention in Corn and Soybean Markets: An Analysis of Program Alternatives." Marshall A. Martin (Purdue University) and Mark A. Edelman (South Dakota State University)
Corn and soybean markets were analyzed with a multiperiod, stochastic simulation model. Elimination of current farm program provisions (deficiency payments, farmer-owned reserves, and CCC operations) increased price levels and variation but substantially reduced U.S. Treasury costs. Elimination of deficiency payments reduced U.S. Treasury costs by one-third but did not affect price behavior.

"Estimating the Effect of Government Programs on the Supply of Wheat in the United States." Bernard F. Neenan (Solar Energy Research Institute) and David Blandford (Cornell University)
Acreage functions for wheat, incorporating variables that reflect the value of voluntary acreage diversion programs to producers, are estimated for 1962–76. The elasticities of response to such programs are generally low in comparison to those for market price, indicating that the reduction of production through voluntary diversion is relatively expensive.

Fruits and Vegetables (Ed Jesse, NED ESS USDA, presiding)

"An Intraseasonal Model of the California Lettuce Industry." Sophia Wu Huang (IED ESS USDA)
An intraseasonal model of the California lettuce industry, consisting of four seasonal models with nine equations for each season, is developed and estimated. Some static and dynamic properties of the estimated model are analyzed.

"Flexible Postharvest Marketing Strategies for Pinto Beans." E. P. King and D. W. Lybecker (Colorado State University)
A model designed to identify optimal postharvest marketing strategies for pinto beans is presented. Both fixed and flexible strategies are evaluated. The flexible strategies use current market information monthly to determine whether or not storage should be continued. They clearly outperform fixed strategies for a risk-neutral decision maker.

"The Market for Winter Tomatoes: A Rational Expectations Interpretation." J. Scott Shonkwiler and Robert D. Emerson (University of Florida)
A model of the Florida tomato industry is formulated under the hypothesis that growers make production decisions as rational economic agents. This assumption implies that anticipated Mexican tomato imports as well as other economic variables are taken into account when the planting decision is made. Maximum likelihood estimation methods are used to solve the simultaneous equations model, and the implications of the model's reduced form are analyzed.

"Specifying a Weekly FOB Price Equation for Fresh Florida Limes." Robert L. Degner and J. Scott Shonkwiler (University of Florida)
Weekly data are analyzed to determine the relationship of Florida fresh lime prices to Florida lime shipments and Mexican fresh lime imports. A dynamic regression or transfer function model is specified for the lime price series. The identified and estimated transfer function models are found to correspond closely, and they highlight the pronounced effect of Mexican lime imports on Florida fresh lime prices.

Food Stamps and Other Food Programs. (Jean Kinsey, University of Minnesota, presiding)

"Food Aid Disincentives and Economic Development: Some Reconsiderations in Light of the Tunisian Experience." Mesfin Bezuneh and Brady J. Deaton (Virginia Polytechnic Institute and State University)

The disincentive effects of total food assistance on the Tunisian economy were analyzed using simultaneous equations. The analysis showed that no significant price disincentives were evident. The authors attributed these results to effective government pricing policy combined with a strong positive relationship between food aid and per capita income.

"The Food Stamp Program as a Categorical Grant: Impact on Participation and Costs." Kathryn A. Longen and Barbara A. Claffey (NED ESS USDA)
The expiration of the Food and Agriculture Act of 1977 in September 1981 suggests debate regarding the funding and operation of the food stamp program. In the past, proposals for a categorical or block grant approach to food assistance have been considered in Congress. This report provides an analysis of changes in benefits and participation under conversion to state administration of a federally funded food stamp program.

"Predicting the Direct Benefits of a Food Price Reporting or Preference Changing Program." W. H. Lesser and W. K. Bryant (Cornell University)
A method is developed for estimating returns to food price reporting and store selection preference-changing programs. The approach is demonstrated by an example. While the estimated return to preference changing is small, the direct savings for price reporting can be substantial. Further replications are required to verify these results.

"Evaluation of Food Consumption Programs: A New Approach." Donald A. West, Leon J. Hunter, and Charlotte B. Travieso (SEA USDA)
Microsimulation modeling allows the effects of food programs and changing socioeconomic and demographic characteristics on household food consumption to be estimated for future time periods. The paper presents the methodology, data base, and specifications needed to develop a framework for assessment of current and proposed food and nutrition programs.

Energy Demand Issues (George Norton, Virginia Polytechnic Institute and State University, presiding)

"Efficiency and Equity Aspects of the Solar Tax Credit and the Role of the Applied Economist." Robert Procter (Michigan State University)
Simulation results are used to argue that the federal solar tax credit violates both the equity and efficiency criterion stipulated by tax theory. We also argue that the efficiency criterion does not provide a useful decision criterion in policy analysis because such policies cannot be used to internalize externalities.

"Profit Volatility and Water-Energy Demand Elasticities in Citrus Production." Gary H. Wilkowske and Gary D. Lynne (University of Florida)
The demand for energy and irrigation water by the Florida citrus industry is shown to be relatively inelastic for energy price increases upward to 300%. As expected, product price increases have a more dramatic effect on profit than do energy price increases. A small product price increase can easily offset a much larger increase in energy prices.

"Economic and Energy Savings from Cogeneration: The Case of Surface-Heated Greenhouses." John B. Braden, Sheryl S. Lazarus, and Paul N. Walker (University of Illinois)
Heating greenhouses by applying waste-heated power plant cooling water to the outside surface could yield natural gas savings of up to 640 million therms and net present value (1980) savings of up to $2.8 billion for the continental United States.

"An Empirical Investigation of the Rural Cooperatives' Residential Demand for Electricity." Ruth J. Maddigan, Wen S. Chern, and Colleen A. Gallagher (Oak Ridge National Laboratory)
This study examines the Rural Electric Cooperatives' residential demand for electricity using a simultaneous-equation, partial-adjustment model. The structural equations are estimated using regionally pooled state-level, cooperative-specific data for the period 1969 to 1977. The results indicate substantial variability among regions in response to changing prices, income, and weather conditions.

Rural Development: LDCs (Eric Monke, University of Arizona, presiding)

"The Farm-Level Impact of Animal Draft Power: Survey Results from Upper Volta." Eric Crawford, David Wilcock, and Gregory Lassiter (Michigan State University)
Based on a 1978/79 survey in eastern Upper Volta, the paper examines the impact of animal traction on area cultivated, cropping pattern, yields, labor use, income, and cash flow. Potential returns to animal traction over time are summarized, and reasons for the gap between current and potential performance are analyzed.

"Tests For Relative Efficiency By Farm Size and Tenure Status of the Main Rice Crop in Bangladesh." Richard F. Nehring (IED ESS USDA)
A restricted profit function is used to estimate profit and factor demand functions from farm level cross-sectional data for the main rice crop in Bangladesh. Analysis indicates that large and small farms are equally efficient and that owners are more efficient in a price and technical efficiency sense.

"Small Farmer Loan Repayment Performance in Nepal." Krishna H. Maharjan (Agricultural Development Bank, Nepal), Chesada Loohawenchit (Thammasat University), and Richard L. Meyer (Ohio State University)

Study revealed that loan supervsion and collection were the most important variables explaining agricultural loan repayment behavior by small farmers in Nepal. Most studies categorize repayment factors into ability and willingness of farmers to repay. Willingness to collect and other institutional problems may be more important in many credit programs.

"Impact on Rural Inequality of Promoting Rural Nonfarm Activities: Evidence from Sierra Leone." Doyle C. Baker (Michigan State University)
This paper reviews evidence from Sierra Leone concerning the effect of promoting rural nonfarm enterprises on rural income disparities. The evidence indicates that policies promoting nonfarm enterprises may have a limited impact on the incomes of poorer rural households and could, in fact, lead to increased rural income inequality.

"A Comparative Method for the Collection of Labor Utilization Data for Secondary Crops: The Example of Cocoyam and Soybean Farming Systems Surveys in West Africa." Hendrik C. Knipscheer (International Institute of Tropical Agriculture, Ibadan, Nigeria)
Labor input data for secondary crops in developing countries are generally unknown because of the high data collection costs. The comparative method is an inexpensive way of labor input derivation where literature research and field surveys are combined. The labor data of selected food staples serve as benchmarks for the estimation of the labor utilization for secondary crops such as cocoyam and soybeans.

Farmland Purchase: Tax and Loan Considerations (Ivery D. Clifton, University of Georgia, presiding)

"The Decision to Buy or Sell Land Affected by Capital Gains and Income Tax Progressivity." John T. Scott, Jr. (University of Illinois)
A present value model estimates farmland price increases needed by investors in different tax brackets to equate land returns to an investment having higher current return but no change in nominal value. Higher bracket investors have greater advantage in land than low bracket investors. Also, inflation enhances this advantage.

"Graduated Payment Schedules For Farmland Purchases." Loren W. Tauer (Cornell University)
Expectation of increasing returns from farmland results in a higher market price than if returns were expected to remain constant. At this higher price, farmland can self-liquidate its own debt only if the payment schedule matches the increasing income stream. Graduated debt payment schedules can be used to accomplish this.

"Customer Profitability Analysis and Farm Loan Pricing by Agricultural Banks." Peter J. Barry and Rick R. Schramm (University of Illinois)
Profitability and pricing of farm loans by agricultural banks are analyzed. An empirical application to farm borrowers of an agricultural bank in Illinois indicates little relationship between customer profits and lending risk, liquidity risk, and other characteristics, thus showing strong potential for more effective loan pricing.

"Shared Appreciation Farm Mortgages: Consequences For Borrowers and Lenders." David Lins (ESS USDA/University of Illinois) and Clair Nixon (Texas A&M University)
Shared appreciation mortgages can help borrowers overcome the initial cash flow problems associated with the purchase of land while providing the lender a hedge against inflation. Procedures for evaluating shared appreciation mortgages versus traditional mortgages and renegotiable rate mortgages are presented.

Macroeconomic Issues in Agriculture (David L. Barkley, University of Arizona, presiding)

"Agricultural Prices in the 1970s and the Quantity Theory of Money." Richard C. Barnett (University of Minnesota), David A. Bessler and Robert L. Thompson (Purdue University)
The paper reviews early work on the quantity theory of money, notes extensions to analysis of relative prices, and tests the theory using Granger's causality definition with 1971–79 monthly time-series measures of U.S. and international money supply and U.S. agricultural prices. Results show money supplies lead prices by eight and sixteen months.

"Effect of Variable Interest Rate Loans on the Agricultural Sector." William McD. Herr, George A. Shumaker, Lyle Solverson, Thomas J. Dougherty, and Stuart Langrehr (Southern Illinois University)
Not only has income variability of important segments of the agricultural sector increased because of variable interest rate loans but this source of variability is significant. Among farm-sector expense items, we found total interest expense to be a major annual expense item and its coefficient of variation is as high or higher as other expense items including fertilizer, petroleum products, and feed.

"Agriculture's Financial Structure, Repayment Ability, and Capital Requirements During Inflation." William Burghardt (Michigan State University) and David L. Watt (IED ESS USDA/Michigan State University)
The agricultural sectors income statement was analyzed for the past thirty years and then projected through 1985 to evaluate agriculture's cash flow position. Then agriculture's debt repayment capac-

ity with and without nonfarm income was analyzed under three different assumed amortization rates.

"A Note on the Theoretical Specification of Wage Rates in a Cost-Push Model of Food Price Determination with Empirical Tests of Causal Orderings." Mike Belongia (NED ESS USDA/North Carolina State University)
Observed increases in nominal factor costs should not cause increased output prices unless nominal input costs increase more than factor productivity. However, cost-push models of food price behavior are often estimated using unadjusted nominal costs. Causality tests suggest adjusted wage growth and price increases are unrelated.

Risk (Mike Boehlje, Iowa State University, presiding)

"Estimation and Analysis of a Survival Function for a Simulated Wheat Farm." Larry J. Held (University of Wyoming) and Glenn A. Helmers (University of Nebraska)
A survival function developed for a simulated wheat farm reflects marginal survival odds decreasing with increased starting equity levels and more conservative borrowing limits for land expansion, but increasing with higher land appreciation rates. Iso-survival relationships show increasing requirements for more conservative borrowing at successively lower beginning equity levels.

"The Impact of Diversification on Farm Risk." Sheldon Zenger and Bryan Schurle (Kansas State University)
Using farm data, this study estimates the relationship between income and variability of income. The effect of diversification and other farm characteristics on income variability also is investigated. Gross farm income, acres per operator, taxable nonfarm income, and machinery investment per acre were significantly related to variability of net income.

"Farm Planning, Risk Aversion, and the Returns to On-Farm Storage Facilities." W. Donald Shurley (University of Kentucky) and George F. Patrick (Purdue University)
Risk is incorporated into an annual farm-planning model using the MOTAD framework. The availability of on-farm storage is an important and often forgotten resource constraint in the sensitivity of farm plans. Because farm plans are affected by risk aversion, so is the importance of storage facilities. Study results were highly sensitive to storage capacity and generally show that returns to storage are highest at low farmer risk aversion.

"A Risk Analysis of the Federal Crop Insurance Act of 1980." Randall A. Kramer (Virginia Polytechnic Institute and State University)
The Federal Crop Insurance Act of 1980 substantially expands the availability of crop insurance and provides for subsidies on premiums. Stochastic dominance is used to evaluate a variety of options available to farmers for using crop insurance to manage production risk.

Natural Resources: Methods (Linda Lee, Oklahoma State University, presiding)

"Common Property, Resource Rent, and Uncertainty: With an Application to the New England Groundfish Fleet." Peter H. Greenwood (University of New Hampshire)
The tendency for competitive users of a common property resource to exhaust the rent the resource is capable of producing has long been recognized. This paper argues that when competitive users must contend with uncertain returns, resource rent is not fully dissipated. When users are risk averse, their expected returns must be sufficiently greater than their certain opportunity costs to compensate for risk. It is argued that the additional returns are in effect a resource rent, since society could at no cost assume the fishermen's risk and appropriate the additional returns without affecting the equilibrium. Using historical data an attempt is made to assess the order of magnitude of risk in the New England otter trawl fishery.

"Bias in Recreation Benefit Estimates: Further Evidence." Kerry R. Livengood (University of Illinois)
Based on data from deer-hunting leases in Texas, a simultaneous model of the demand for deer-hunting trips, time spent at hunting sites per trip, and actual hunting lease cost is compared to demand derived by the travel cost method. The results suggest that bias associated with estimates of willingness-to-pay increases as travel cost decreases.

"Methodological and Empirical Considerations for Incorporating Fishing Power Functions in Bioeconomic Models." Timothy G. Taylor and Fred J. Prochaska (University of Florida)
The "correct" measurement of fishing effort is essential for the successful construction of fishery production and stock assessment models. A general method for measuring fishing effort in standardized terms on the basis of a fishing power function is presented. The results suggest this methodology to be superior to traditionally used effort measures.

"Methodological Ethics in the Evaluation of Nonmarket Goods Allocations." J. Walter Milon (University of Florida)
The ethical basis for economic evaluations of alternative nonmarket goods allocations is examined in terms of the treatment of property rights and intergenerational effects. The author argues that the theoretical and empirical conventions commonly adopted by resource economists are ethically biased and these ethical issues are worthy of more extensive debate.

"A Theoretical Model of Overgrazing in Traditional Livestock Economies of Africa: A Paradox of Perceived Values." G. M. Sullivan (Auburn University), K. W. Stokes and D. E. Farris (Texas A&M University)
Communal grazing is the major barrier to development of livestock economies in Africa. With a theoretical model, the paradox in a producer's perceived values for inputs and outputs in his livestock operation is examined to explain overgrazing. Analysis of government policies indicate improved livestock systems require appropriate institution building.

Livestock Sector Analysis (Terry Roe, University of Minnesota, presiding)

"The Hog Cycle Revisited." Thomas H. Spreen and J. Scott Shonkwiler (University of Florida)
The existence of a four-year cycle in hog production and prices has been well documented in the literature. Using recent data, however, this paper demonstrates that the cycle has become shorter with an average duration of approximately 3.2 years.

"The Economic Homogeneity of Grade Classifications Under the New and Old Feeder Cattle Grading Systems," James N. Trapp (Oklahoma State University)
A methodology was developed to determine the degree of economic homogeneity of a given grade class. A more homogenous grade grouping is argued to be desirable. The new feeder cattle grading system was found to provide a 12.5% less homogenous basic grade group class than the old system.

"A Disequilibrium Model of the U.S. Fed Beef Sector." Rod F. Ziemer and Fred C. White (University of Georgia)
In this paper current theory and estimation procedures are applied in an analysis of disequilibrium price behavior in the U.S. fed beef sector. Although tests of equilibrium versus disequilibrium hypotheses are not well developed, results indicated the possible presence of disequilibrium prices in the market for fed beef; at least the hypothesis of significant disequilibrium could not be rejected.

"Evaluating the Countercyclical Aspects of the U.S. Meat Import Act of 1979." James R. Simpson (University of Florida)
The potential effect of the new U.S. meat import law is analyzed under two radically different assumptions about buildup in U.S. cattle inventory. It is concluded that the bill is not truly countercyclical in nature because it only operates that way under special circumstances.

Food Demand (J. B. Wyckoff, Oregon State University, presiding)

"Life Cycle Effects on Household Away-From-Home and At-Home Food Expenditures." Stanley M. Fletcher (University of Georgia)
The influence of socioeconomic factors on food expenditures previously has been examined somewhat in isolation. The relative extent to which socioeconomic factors influence away-from-home and at-home food expenditure patterns across a household's life cycle was empirically investigated using the 1972–73 BLS Consumer Expenditure Diary Survey as the data base.

"Food-Away-From-Home Expenditures By Source of Household Income." Jean Kinsey (University of Minnesota)
Marginal propensities to consume (MPC) food away from home (FAFH) out of six sources of household income were estimated using Tobit and OLS. Marginal propensity to consumer FAFH was increased by income earned by children and part-time working wives and by transfer income in 1978. Full-time working wives' income decreased MPC.

"The Contribution of Basic Need Theory to Household Decision Making." Dorothy Z. Price and David W. Price (Washington State University)
Utility is viewed as consisting of five basic needs: physiological, security, love and belongingness, self esteem, and self actualization. Empirical applications are given in the areas of food consumption, food stamp participation, and job satisfaction. Potential value for integrating these psychological and economic constructs is discussed.

"Estimation of a Complete Disaggregate Food Demand System in the United States." Kuo S. Huang (NED ESS USDA)
Statistical procedures for computing the parameters of a highly disaggregated food demand system are developed. The procedures are then applied to the estimation of a U.S. food demand system consisting of forty-two commodities and one nonfood sector. Data are annual observations for 1953–77.

Economies of Farm Size (Sidney Bell, Auburn University, presiding)

"Impact of Selected Federal Tax Provision on the Growth of Two Cash-Grain Farms Differing in Size." Boris E. Bravo-Ureta (University of Connecticut) and Glenn A. Helmers (University of Nebraska)
A mixed-integer-polyperiod linear-programming model is used to evaluate the impact of selected federal tax provisions on the growth of two cash-grain farms. The results indicate that taxes differentially affect the growth of farms varying in size and thus can be important in determining the structure of cash-grain agriculture.

"Interfarm Variation of Cost of Production and Transportation, Yields, and Net Farm Income in the Canadian Prairies: An Econometric Analysis." Ihn H. Uhm and Andrew W. Gemmell (Research Branch, Canadian Transport Commission)
Size is the most important source of interfarm variation in the cost of grain production and transportation and in net income. Average transportation cost is a decreasing function of output, augmenting economies of size. Findings from the cost, yields, and net income models are consistent between single and multicrop samples.

"Resources and Economic Efficiency of Small and Large Farms: Selected Farms in Tennessee." Surendra P. Singh and Handy Williamson, Jr. (Tennessee State University)
The major objective of this study is to determine possible differences between production functions and differences in productivity levels as means to appraise resource allocative efficiency on small and large farms. Cobb-Douglas production functions were estimated using cross-section data collected from 193 randomly selected farm families in two counties of west Tennessee. The empirical results reveal that significant differences exist between the groups of farms. These differences are reflected by production functions and production elasticities of individual inputs.

"Estimates of before- and after-Tax Scale Economies for a Sample of Illinois Cash Grain Farms." Marvin T. Batte (Ohio State University) and Steven T. Sonka (University of Illinois)
The primary purpose of this study was to investigate the degree of economies of scale existing on a before- and an after-tax basis for a sample of commercial Illinois farms. Results of the analysis indicate substantial scale economies both before and after taxes for this sample of cash grain producers.

Marketing Issues (Ron Mittelhammer, Washington State University, presiding)

"Factors Influencing the Diversification of Food Manufacturers." James M. MacDonald (ESS USDA)
Product diversification, a common phenomenon, has been the subject of few empirical studies. I discuss issues in the definition and measurement of diversification, and then provide estimates of its extent among food manufacturers in 1975. Finally, I provide a statistical analysis of the differences across firms in the extent of diversification.

"An Evaluation of Alternative Indicators of Commodity Instability." Susan E. Offutt and David Blandford (Cornell University)
Data on ten U.S. field crops for the period 1950–77 are used to determine whether alternative single variable measures provide the same assessment of relative variability. The results demonstrate that the measurement and analysis of instability may be highly dependent on the choice of indicator.

"Theoretical and Empirical Considerations for Price Margins: An Application to the Striped Bass Market." Ivar E. Strand, Jr., and Robert E. Chambers (University of Maryland)
Using assumptions of competition and market equilibrium, a theoretical model of price margin behavior was constructed. Duality theorems with traditional comparative static analysis offered a specification of price margins in terms of shifters of supply and demand. The model was tested using wholesaler margins for East Coast striped bass. Factors positively related to marketing volume increased margins whereas those negatively related to volume reduced margins.

"An Empirical Analysis of the Cost of Long-Term Debt Financing for Cooperative and Proprietary Agricultural Marketing Firms." Peter Vitaliano (Virginia Polytechnic Institute and State University)
Regression analysis relating four measures of the cost of long-term debt financing to capital structure and other financial factors reveals this cost to be generally, but not in every circumstance, unrelated to a marketing cooperative's debt ratio and, in many instances, greater than this cost for a comparable proprietary firm.

"A Proposed Monitoring System for Detecting Violations of Capper-Volstead, Section 2." Edward V. Jesse (NED ESS USDA) and Aaron C. Johnson, Jr. (University of Wisconsin)
This paper presents a systematic procedure for monitoring agricultural marketing cooperatives for evidence of Capper-Volstead section 2 violations—unduly enhanced prices resulting from monopolization or restraint of trade. A screening process is proposed to identify cooperatives processing monopoly power as well as the ability to exercise monopoly power.

Regional Analysis (Craig L. Infanger, University of Kentucky, presiding)

"Sample Selection and the Problem of Unstable Base Relationships in Forecasting." William Gillis (University of Wisconsin)
Many regional analysts utilize econometric economic base models to estimate income multipliers in nonmetropolitan communities. Unstable base relationships caused by structural change within regional economies reduces the accuracy of forecasts derived from econometric results. This study applies a data pooling procedure to control the problem of unstable base relationships in forecasting.

"The Influence of Input Supply and Output Demand on Industrial Growth in the Rural Communities of Pennsylvania." Steven E. Hastings (University of

Delaware) and Frank M. Goode (Pennsylvania State University)
An important concept in location theory is the availability of intermediate inputs. This paper presents a conceptualization of intermediate input supply and suggests a variable to operationalize this concept. The variable is empirically implemented to test the relationship between the availability of intermediate inputs, market access, and industrial growth in rural communities.

"The Spanish Agricultural Growth Model: Implications for the Future." Philip F. Warnken and Charles C. Crissman (University of Missouri)
Spanish agricultural output has expanded at an average annual rate of 4% since 1960. In the absence of domestically generated technology, imported technology and imported agriculture inputs have been significant growth sources. Recent public policy emphasizing domestic technology generation promises potential for rapid future growth of Spain's agricultural output.

"A Model for Determining the Impact of Federal Outlays on County Well-Being." Marlys Knutson Nelson (EDD ESS USDA) and Luther G. Tweeten (Oklahoma State University)
A model is presented for evaluating federal spending to enhance well-being as proxied by personal income per capita, employment rate, private investment per capita, and population change. An application is illustrated. Based on results, it appears that federal programs are not highly effective in promoting the goals examined, and ways need to be explored to improve their performance.

Water Use and Quality (John Braden, University of Illinois, presiding)

"Special Assessment Tax for Water Quality Improvement." Nicolaas W. Bouwes, Sr. (NRED ESS USDA) and Peter Caulkins (University of Wisconsin)
Although it is recognized that there exists an unequal distribution of benefits associated with urban lake improvement projects, financing of such property typically relies on uniform property taxes which do not make this distinction. In this paper a more equitable tax, based upon a property value impact model, is proposed in which costs levied are commensurate with benefits received.

"Issues in Subsidization of Agricultural Nonpoint Pollution Control." William M. Park and Leonard Shabman (University of Tennessee)
Potential program cost savings in the form of reduced subsidy payments are estimated for a case study area from (*a*) targeting on the basis of land attributes and (*b*) increased education efforts. Discussion is also directed to the trade-off with increases in (*a*) information, contracting, and policing costs and (*b*) information and education costs.

"Efficiency and Equity Aspects of Policies to Control Sediment in the Altamaha River Basin in Georgia." Stan Spurlock and Ivery D. Clifton (University of Georgia)
Impacts on net farm income from policies to control sediment are analyzed with a linear programming model. Both efficiency and equity implications are presented under two policy alternatives. The level of subsidization for construction of terraces and alternative impacts when pollution abatement practices are implemented at the farm versus the basin level are analyzed.

"Residential Water Consumption with an Increasing Block Rate Structure." C. E. Young (NRED ESS USDA) and K. R. Kinsley and W. E. Sharpe (Pennsylvania State University)
Demand functions are estimated for the pre-rate change period using an error components regression procedure. Assuming no change in the rate structure, water use is predicted for the post-rate change period. Comparison of these use levels indicates that water use declined due to the imposition of the new rate.

Teaching, Extension, and Professional Activities (Larry Bohl, Purdue University, presiding)

"A Teaching Tool for Making Elasticity Relevant." David E. Kenyon and Karen P. Mundy (Virginia Polytechnic Institute and State University)
This paper explains the self-learning unit, "Forecasting Hog Prices Using Elasticities." It discusses the format of the self-learning unit, its forecasting ability, and its strengths and limitations for teaching a practical application of elasticities.

"Ethics, Research and the Agricultural Economist." David L. Debertin, E. Jane Luzar, and Eldon D. Smith (University of Kentucky)
The adherence to accepted canons of evaluation, or protocols, are distinguishing marks of scientific inquiry. Agricultural economics faces special problems which makes self-policing more difficult than in the non-social sciences. This paper examines reasons why research ethics should be of greater concern to agricultural economics. Case examples of situations involving ethics in research are examined.

"Comparing Loans: An Extension Program." Kim B. Anderson and Garnett L. Bradford (University of Kentucky)
The objective of this paper is to present a procedure for comparing alternative loans with different and/or unequal loan fees. The procedure is adaptable for use with calculators or microcomputers. An adjusted total loan cost and an approximate effective annual interest rate is produced for loan comparison.

"Determinants of Agricultural Economics Faculty Salaries." Josef M. Broder and Rod F. Ziemer (University of Georgia)
This paper reports findings of a study of agricultural economics faculty at land grant universities. Research and teaching activities are measured along with selected categories of faculty productivity. Within the context of a general salary model, monetary returns to research, teaching, and grantsmanship are examined along with other salary determinants.

"Migration Patterns of Students Receiving Ph.D. Degrees in Agricultural Economics in the United States." R. A. Schrimper (North Carolina State University)
The importance of different types of undergraduate institutions and interinstitutional migration patterns for individuals awarded Ph.D. degrees in agricultural economics is examined. A declining importance of land grant universities as a source of students, increased interinstitutional migration, and little change in time lags between degrees are indicated.

Rural Development: Public Services and Finance (Paul Gessaman, University of Nebraska, presiding)

"Distributional Aspects of a School Finance Formula among School Districts." Donald D. Osburn (University of Missouri)
This study was concerned with the school finance systems' recognition of differences in the local school district's ability to finance education. More specifically, this research was concerned with determining the effectiveness of the state aid formula (a new formula) in improving fiscal equity in Missouri school finance. The three measures of fiscal equity used in this study were expenditure uniformity, tax power equity, and wealth neutrality.

"Factors Influencing the Financial Viability of Nonprofit Primary Health Care Centers." Andrew C. Hunter and Sam M. Cordes (Pennsylvania State University)
Data were gathered in 1978 from seventy nonprofit primary health care centers (PHCCs) in Pennsylvania. These data were used for analyzing the financial viability of PHCCs. Financial viability is enhanced if the center (*a*) is not located near other physicians, (*b*) does not have a quality assurance program, and (*c*) is not overcommitted to administrative resources.

"Statewide Reassessment and Preferential Assessment of Agricultural Land: The Effects on Property Tax Incidence in Missouri." David E. Ervin (University of Missouri) and Robert M. Schoening (Milk Market Administrators Office, St. Louis, Mo.)
Recent appreciation of real estate values has unevenly eroded assessment levels from legal standards in many states. Inflation also has affected the determination of use values for agricultural lands. For Missouri counties, general reassessment is estimated to cause sizeable property tax shifts which ultimately would alter public service demands.

"The Direct and Indirect Effects of Population Growth on Homeowner Property Taxes." Shepard C. Buchanan and Bruce A. Weber (Oregon State University)
A model for estimating the direct and indirect effects of population growth on property taxes is fit to data for Oregon counties. Results suggest that increases in population did lead to increases in homeowner property taxes in the mid-1970s, primarily through the effect of population on assessed values.

Transportation Rate Structures (Phillip Baumel, Iowa State University, presiding)

"Ocean Freight Rate Variability as a Factor in International Agricultural Trade." James K. Binkley (Purdue University)
Due to inelastic shipping supply, ocean freight rates can fluctuate significantly over short periods. This variability can affect trade analysis. This paper presents evidence on rate variability and discusses possible implications for welfare gains from price stabilization and free trade, for comparative advantage, and for the effects of market power.

"Effectiveness of Competitive Forces to Limit Rail Rate Increases on Export Wheat Traffic in South Plains." Stephen Fuller and C. V. Shanmugham (Texas A&M University)
The paper relates results of research conducted to determine the effectiveness of competition to limit increases in rail rate levels under conditions of rail deregulation. The study focuses on the ability of intramodal and intermodal competition to constrain rail rate increases on South Plains export wheat movement.

"Estimation of Demand for Truck-Barge Transportation of Pacific Northwest Wheat." Charles Logsdon (Alaska Department of Revenue), Ken Casavant, Ron C. Mittelhammer, and LeRoy Rogers (Washington State University)
A conditional choice model was used to analyze truck-barge transportation demand. Truck-barge demand was found to be own-rate elastic but inelastic to rail rate changes. Transit time, equipment availability, and variance in waiting time were far less important compared to rates in determining modal choice.

"Factors Associated with Grain Rail Rates in Three U.S. Rate Territories." Michael J. Pesch and Donald W. Larson (Ohio State University)
Through regression analysis, the variability of grain

rail rates in three rail rate territories was found to be significantly explained by shipment size, traveling distance, and rail rate territory. Study results are discussed as they relate to the Staggers Rail Act of 1980 and alternative pricing policies.

"An Alternative Rate Structure for Assembling and Hauling Bulk Milk in Vermont." Fred Webster and Edward Karpoff (University of Vermont)
A revised rate structure for bulk milk hauling from Vermont farms is presented. Overcharging large-volume producers in favorable locations for milk hauling causes them to change haulers. Overhead costs per unit are thereby raised for remaining shippers. Revised rate structures could defer such a shift and help small farms.

Marketing Livestock and Grain (Lowell Catlett, New Mexico State University, presiding)

"Marketing Slaughter Hogs by Remote-Access Computerized Auction: Theory and Empirical Results." Dennis R. Henderson and E. Dean Baldwin (Ohio State University)
Electronic markets have been suggested as one means of reducing impacted pricing problems associated with thin, transparent trading of agricultural products. An experimental daily electronic auction was initiated for slaughter hogs in Ohio. Results in first four months show competitive price enhancement, improved price-quality relationships, and greater pricing efficiency.

"Electronic Meat Trading: Some Economic Considerations and Evaluation Guidelines." M. E. Sarhan (University of Illinois) and Kenneth E. Nelson (NED ESS USDA/University of Illinois)
The traditional exchange system for wholesale meat in the United States is under attack, partly because of alleged inefficiencies and equities in pricing. New marketing alternatives are under consideration, including electronic trading. This paper reviews the potentials of electronic trading for meat and suggests some economic considerations and evaluation guidelines.

"Distributional Aspects of the Farmer-Owned Grain Reserve under Alternative Risk Hypotheses." Andrew Morton, James Langley, and Earl O. Heady (Iowa State University)
A present-value certainty equivalence approach is used to assess the potential distributional aspects of participating in the farmer-owned reserve across farm size under risk. Even if the risk discount increases with farm size, other aspects favor participation of large producers enough to outweigh the risk factor.

"Managerial Inefficiencies in Rationalized Grain Marketing Systems." A. Clyde Vollmers and Stanley Thompson (Moorhead State University)
Economically inefficient managerial decisions may reduce the savings which rationalization of grain-marketing systems could potentially generate. Ineffective distribution, ownership, or transshipment patterns or modal selection decisions were estimated to total 3% of the marketing cost in one Michigan region. Thus, institutional design is critical in implementing system rationalization.

"The Impact of the Farmer-Owned Reserve on Market Structure: The Case of Wheat." William H. Meyers (Iowa State University) and Abner W. Womack and Maury E. Bredahl (University of Missouri)
The farmer-owned reserve is modeled as an endogenous variable in an econometric wheat model, and reduced-form impacts are obtained. The reserve equations, which are price elastic, add substantially to the elasticity of total market demand and significantly alter the impacts of exogenous shocks on price and other endogenous variables.

Farm Management Issues (Bill Boggess, University of Florida, presiding)

"Modeling Optimal Replacement Decisions for Farm Machinery: Some Theoretical and Empirical Problems." Garnett Bradford and Donald Reid (University of Kentucky)
Machine replacement research has concentrated on delineating and comparing present value (PV) and derived marginal analysis models. With such, one encounters problems in generating reliable estimates of new and used machine prices, repairs, and opportunity costs. Some empirical problems may be surmounted by altering the traditional PV framework, but theoretical considerations require more comprehensive models.

"The Economic Threshold as an Investment Problem." Mark Cochran and Lindon J. Robison (Michigan State University)
This paper develops the argument that the determination of the economic threshold and the underlying procedure defining optimal pesticide use is in reality a durable investment problem. It provides a conceptualization of the economic threshold that can guide research in the area to define more accurately the problem of optimal chemical usage.

"Multistage Optimization Using Separable Programming." Corbet J. Lamkin and W. Lanny Bateman (Mississippi State University)
This paper presents a case study of an integrated poultry firm with a plant location problem where two distinct processing functions are necessary and each process is subject to size economies. The problem was approached using separable programming. Results showed that separable programming is effective for problems involving multistage processing.

"Farmers' Goals: Uni- or Multi-Dimensional?" George F. Patrick and Brian F. Blake (Purdue University) and Suzanne H. Whitaker (Indiana Farm Bureau Cooperative)
Common goal measurement techniques implicitly assume farmers order goals on a unidimensional hierarchy. Multidimensional scaling (MDS) is proposed as an alternative conceptualization and scaling procedure. MDS scalings of farmers' goals were more consistent than with other methods. Risk-growth, monetary versus nonmonetary and wishfulness-practicality continuums were three dimensions identified.

Farmland Values and Conversion (Nelson Bills, NRED ESS USDA, presiding)

"Landowner Characteristics as Determinants of Developer Locational Decisions." Charles H. Barnard (NRED ESS USDA)
Discriminant and regression analysis show that the personal and financial characteristics of current landowners determine which urban fringe parcels developers select first. Normal conditions within the urban land market lead developers to choose those parcels that are owned by individuals with relatively low perceived present values for their parcels.

"A Market Equilibrium Approach to Determining Land Values." Lindon J. Robison and Thomas K. Espel (Michigan State University)
Models are developed for determining land prices in Walrasian market settings where land supplied and demanded is dependent on expected costs and expected benefits. The models, after being logically deduced, are tested empirically. The inflationary model without fixed land supply is validated empirically. The model including fixed land supply is rejected.

"A Pooled Time-Series Cross-Section Analysis of Land Prices." Jean-Paul Chavas and C. Richard Shumway (Texas A&M University)
Based on a theoretical formulation of land price formation as an economic rent to a fixed input, a single-equation econometric model is specified and estimated to explain land prices in five Iowa crop-reporting districts. It identifies the influence of farm prices, inflationary pressures, as well as land quality on the price of land.

"Analysis of Factors Affecting Rural Real Estate Values in Eastern Oklahoma." James R. Nelson and William E. Burton (Oklahoma State University)
The objective of the study reported was to examine factors that cause variations in rural real estate values in an eastern Oklahoma study area. Econometric models were developed to explain values of study area rural real estate in general and agricultural and nonagricultural real estate in particular.

Research, Development, and Technological Change (Carl E. Pray, University of Minnesota, presiding)

"An Analysis of Research Expenditures for Selected Agricultural Commodities." Nathan M. Garren (North Carolina State University) and Fred C. White (University of Georgia)
The empirical results of this study indicate the presence of externalities in agricultural research expenditures. An analytical framework is developed to account for these externalities in the allocation process. Allocations are examined both from the perspective of the state, acting in its own best interest, and from the nation's perspective.

"The Use of Genetics Principles in Research Evaluation—An Example with Soybeans." George W. Norton (Virginia Polytechnic Institute and State University) and W. B. Sundquist (University of Minnesota)
This paper explores the potential use of quantitative genetics principles in evaluating economic returns to plant-breeding research. Basic factors affecting genetic progress are described along with possibilities for quantifying them in relation to research expenditures. An example with soybeans illustrates how this information can be incorporated into *ex ante* research evaluation.

"An Economic Assessment of the Impacts of Public Funded Research on Corn, Soybeans, Sorghum, and Wheat." Daniel M. Otto and Joseph Havlicek, Jr. (Virginia Polytechnic Institute and State University)
The framework of a supply response model is used to evaluate individually the impacts of research expenditures on yields of corn, wheat, soybeans, and sorghum. Based on pooled data from a cross-section of states for the 1973–79 crop years, the Parks procedure was used to estimate internal rates of return of 71%–97% for own-state investment and 5%–47% for spillovers of outside research investment. Yield-response price elasticities indicate wheat yields were most responsive and sorghum yields were least responsive.

"Crop Improvement Strategy: An Analysis of the Potential Benefits of New Cassava Production Technology in Colombia." Douglas Pachico (International Center for Tropical Agriculture, Cali, Colombia)
The potential benefits of cassava varieties suitable for the feed market are estimated. A linear programming feed-mix model simulates the cost reduction in feed resulting from cheaper cassava. Then, elasticities of demand and supply of poultry are estimated to calculate economic surplus from the new technology.

"The Impacts of Government Production-Oriented Research and Extension on U.S. Agriculture: A Simulation of Future Alternatives." Roland K. Roberts (University of Hawaii) and Raymond Joe Schatzer and Earl O. Heady (Iowa State University)

This paper explores the effects on U.S. agriculture of alternative future assumptions relating to the growth in real government expenditures on production-oriented research and extension. Results suggest that increases in the rate of growth in research and extension above-average historical levels could cause agricultural prices and incomes to decline substantially. However, crop exports would only have to increase above projected trend levels by approximately 6.5% to maintain crop prices.

Pest Management (Katherine Reichelderfer, NRED ESS USDA, presiding)

"A Simple Model to Determine the Economic Threshold of Beef Cattle Pests with Limited Entomological Information." Assam M. Azzeddine and Maurice Baker (University of Nebraska)
Existing models for defining the "economic threshold" for pest control have been developed largely for crop damage assessment and require data not presently available. These models are modified to construct a workable approach to a livestock pest problem based on limited entomological information.

"Estimating Benefits from Controlling Nuisance Pests: An Application of the Iterative Bidding Technique." Darrell Hueth (Oregon State University), Steve Voorhees (University of Wisconsin), and Richard Casagrande (University of Rhode Island)
This paper presents some results on the application of the iterative bidding technique to estimating benefits from reducing gypsy moth infestations in the Northeast. Benefits are calculated under the assumptions that (*a*) a chemical spray is the only control technique variable, and (*b*) that there exists some completely environmentally safe technique for controlling the pests. The difference between estimates and benefits obtained under these two situations is interpreted as the estimate of environmental cost resulting from using chemical sprays. Also, this research is generally encouraging insofar as the usefulness of the iterative bidding technique itself is concerned in that the empirical results are largely consistent with a priori theoretical hypotheses.

"The Contribution of Herbicides and Other Technologies to Soybean Production in the Corn Belt Region, 1965 to 1979." David Schroder, J. Charles Headley, and Robert M. Finley (University of Missouri)
This report attempts to identify the contributions of technology and weather to soybean yield variation for the period 1965 to 1979 in the Corn Belt. Technology variables included genetic improvement, herbicides, and row-width. A pooled, cross-sectional, time-series data base was used to estimate regression parameters for herbicides and other variables. A marginal private benefit/cost return of $2.3 per dollar of herbicide cost was estimated for additional land treated with herbicides.

"Use and Benefits of Kalman Filtering for Insect Pest Management." Luis R. Zavaleta and Bruce L. Dixon (University of Illinois)
Efficiency of pest scouting is shown to be increased substantially by utilizing a model of pest evolution between sampling periods in addition to sampled data. The Kalman filter is the estimator used, applied to the bean leaf beetle in Illinois.

Input Demand (Lee F. Schrader, Purdue University, presiding)

"A Canonical Correlation Analysis Relating Farmer Characteristics to Service Demand in the Purchase of Farm Inputs." L. A. Johnson and W. A. Thomas (University of Georgia)
The purpose of this paper was to identify farmer characteristics which affect demand for farm services. Data included surveyed responses from 277 farmers located in selected southeastern areas. The canonical correlation procedure was used to test the assumption that the characteristics were not independent of each other.

"Optimal Asset Replacement under Conditions of Technological Change: The Case for Improved Fuel Efficiency." F. Allen Morris (A. Duda & Sons)
This study analyzed the effects of technological change, measured as improved fuel efficiency, on the optimal timing of replacement for pickup trucks used on corporate farms. It was found that annual mileage, fuel price, and level of fuel efficiency of potential replacements all affect optimal replacement times.

"Demand Elasticities and Cross Elasticities for Diesel Fuel—Crop Producers." Francis P. McCamley and James B. Kliebenstein (University of Missouri)
A quadratic programming model was formulated to examine diesel fuel demand by a representative risk-averse crop producer. Demand was examined by varying energy prices, crop prices, and degree of risk aversion. Wheat and soybean prices and producer's attitude toward risk had greater impacts on fuel use than energy prices.

"Demand for Farm Tractor Horsepower in the United States." Dennis M. Conley and Douglas A. Lambert (University of Illinois)
Since the mid-1960s there has been a shift in the composition of tractor horsepower purchases. Models of annual demand were estimated for the 1950–78 time period. Significant explanatory variables included tractor prices, prices received, stock of horsepower on farms, interest rates, farm employment, self-propelled combines, and acres planted.

Econometrics (Peter Greenwood, University of New Hampshire, presiding)

"Detection and Treatment of Multicollinearity in Simultaneous Systems of Equations." Ralph R. Semprevio (Chase Econometrics) and Oral Capps, Jr. (Virginia Polytechnic Institute and State University)
Methods to detect the extent of multicollinearity in simultaneous systems are put forward. To treat multicollinearity problems, the integration of the Ridge Regression technique with the 2SLS technique is proposed. The RR2SLS procedure is then empirically evaluated vis-à-vis the 2SLS procedure.

"Prior Linear Constraints on Parameters: Will Their Use Mitigate Specification Error?" Ron C. Mittelhammer (Washington State University)
The paper defines the theoretical problem conditions under which restricted least squares (RLS) is superior to OLS in predictive risk when misspecification exists. Unfortunately for applications, the *F*-test of RLS superiority is biased and has undesirable power characteristics, and the use of correct prior constraints can accentuate predictive risk.

"Criteria for Model Specification of Demand Systems." Oral Capps, Jr., and Joseph Havlicek, Jr. (Virginia Polytechnic Institute and State University)
Four general principles are formulated as criteria for model specification of demand systems. The concepts shed light on systems credibility, validation, strengths, and weaknesses. The principles are used to judge the empirical performance of the S_1-branch system.

"Error Specification in Transformed Models." David Smallwood and James Blaylock (FE NED ESS USDA)
Autocorrelated residuals and a heteroskedastic error variance are both jointly and separately incorporated into a Box-Cox transformed model. A quarterly demand equation for pork is used for purposes of illustration. Results indicate that both functional form and error term specification play a crucial role in hypothesis testing and estimation of elasticities.

Soil Erosion (David J. Walker, University of Idaho, presiding)

"A Regional-National Model for Agricultural Policy Analysis with an Application to the State of Iowa." Wen-yuan Huang (NRED ESS USDA) and James A. Langley and Earl O. Heady (Iowa State University)
A Regional-National Model has been constructed and can be used as a tool to estimate the regional effects of a national policy and to evaluate the national implications of regional policy alternatives. A Regional-National Model of soil erosion in Iowa is presented as an illustration of this modeling technique.

"Risk Perceptions and the Utilization of Conservation Tillage Practices." James S. Shortle and John A. Miranowski (Iowa State University)
The relative risk of alternative tillage practices perceived by farmers and the determinants of these perceptions are considered. Survey data are used to estimate relations between perceptions of relative risk and farm operators' human capital and farm operation variables. The implications for effective soil erosion control policy are discussed.

"Impact of Erosion Control Policies on Wildlife Habitat on Private Lands." John A. Miranowski and Ruth Larson Bender (Iowa State University)
This study indicates that erosion control policies designed to maintain soil productivity and improve water quality tend to enhance wildlife habitat quality with varying degrees of effectiveness. Habitat indexing and valuation procedures are considered in conjunction with a programming model of the Iowa River Basin to illustrate these effects.

"The Influence of Technological Progress on the Long-Run Social Returns to Soil Conservation." Daniel Taylor, Douglas Young, and David Holland (Washington State University)
Appropriate multiplicative interaction between technological progress and yield-topsoil functions was incorporated in a systems simulation model projecting Palouse topsoil levels, crop yields, and net incomes. Results revealed high payoff to soil conservation on shallow soils and for longer planning horizons. Yield projections were more optimistic than farmers' subjective projections.

International Trade (Robert Chambers, University of Maryland, presiding)

"U.S. Trade in Consumer Products." Philip Garcia, Mary Anne Ross, and Daniel I. Padberg (University of Illinois)
The United States has experienced a large trade deficit in consumer products. It is hypothesized that the institutional frameworks in which consumer products are marketed have adversely affected our trade in consumer products. Trade policy alternatives should recognize these institutional differences and their implications for our trade situation.

"Effects of European Export Subsidies on Changing Levels of U.S. Poultry Meat Exports in World Markets." Glenn C. W. Ames and John W. McClelland (University of Georgia)
The European Community (EC) is the world's largest exporter of poultry meat and eggs. EC export subsidies have lowered the effective price of poultry exports and expanded the demand for its product. As a result there has been a substantial substitution of EC poultry for U.S. products in world markets.

"Developing a Prototype Model for the World Grains, Oilseeds, and Livestock Model." Karen Liu (IED ESS USDA)
In order to develop an improved specification for the grains, oilseeds, and livestock world trade model and to cope with the problems identified in the present GOL model, an aggregate three-commodity, two-region prototype model is developed. The major emphasis on the model structure is using nonlinear functional forms and incorporating trade restrictions in the model.

"The Effect of Bilateral Trade Agreements on World Trade and Price Stability." Alan J. Webb (IED ESS USDA)
A theoretical model is developed which shows that the aggregate effect of an increase in bilateral trade agreements is an increase in the variability of world prices and trade. For a single country, the model shows that it is to each country's advantage to keep its bilateral commitments from exceeding its expected trade.

"The Impact of Structural Change on Potential Instability in the World Wheat Market." Nancy E. Schwartz and David Blandford (Cornell University)
The relative decline in wheat consumption in the developed countries is reducing the potential stabilizing effect on the world market of freer trade in these countries. Furthermore, the growing role of centrally planned countries as importers is increasing the potential instability in world wheat import demand.

Labor (James Holt, Consulting Agricultural Economist, Washington, D.C., presiding)

"Econometric Simulation Approach to Evaluating the Impact of a Technological Change." Jon A. Brandt (Purdue University) and Ben C. French (University of California, Davis)
An econometric model of the processing tomato industry simulates price, production, and employment levels with and without adoption of the mechanical tomato harvester. Acreage increased by 30,000 to 85,000 acres, and grower prices declined by $6.84/ton to $19.51/ton with harvester adoption. Displaced harvest labor was largely offset by increases in assembly and cannery employment.

"Farm Household Production: Demand for Wife's Labor, Capital Services, and Capital-Labor Ratio." Mark Lange (St. Cloud State University) and Wallace E. Huffman (Iowa State University)
Model of farm household resource allocation and econometric estimates of equations explaining absolute and relative factor intensities of household production are developed. Empirical results indicate the gross substitute nature of wife's household labor and capital services. Importance of separation of home labor and leisure are also demonstrated.

"An Econometric Analysis of the Market for Casual and Other Hired Farm Labor." Lewell Gunter and Ann Vandeman (University of Georgia)
This is a time-series supply and demand analysis with hired farm labor disaggregated into casual and noncasual categories. Man-days worked is used as an endogenous variable rather than the number of workers. The model specification and data source differ from previous studies and results are compared to previous studies.

"Off-Farm Labor Supply in a Developing Economy." Dwight A. Smith and Richard L. Meyer (Ohio State University)
This paper reports on a study testing the new household economics for explaining off-farm labor supply of a sample of Philippine farm households. Labor supply for husbands was very elastic with respect to off-farm wage rates. Farm size and number of children were also important explanatory variables.

Synthetic Fuels (Loyd Fischer, University of Nebraska, presiding)

"The Feedback Effects of Higher Oil Prices on Production of Biomass Alcohols and Synfuels." John D. Hoff and Wallace E. Tyner (Purdue University)
A biomass alcohol sector was added to an energy macromodel to examine the effect of oil price feedbacks on the production costs and development of biomass alcohols and synfuels derived from oil shale and coal. Coal liquids costs were most sensitive to oil price increases, while biomass alcohol costs were least sensitive.

"Market Implications of Soybean Oil Use as a Diesel Fuel Substitute." Richard A. Levins (Mississippi State University) and William H. Meyers (Iowa State University)
Soybean oil is being considered as a diesel fuel substitute by both the United States and Brazil. Impacts of a fuel substitution program by each country on the U.S. soybean industry are evaluated. Export values and oil prices increase, but there are negative impacts on the meal sector.

"A Comparison of the Economic and Technical Potential of Small-Scale Alcohol and Sunflower Oil Production." Robert C. Reining and Wallace E. Tyner (Purdue University)
The technical and economic feasibilities of three scales of on-farm grain alcohol production are compared with three similar scales of sunflower oil production. Sensitivity analysis is conducted for different operating conditions, feedstock costs, and byproduct values. Sunflower oil is generally competitive with alcohol if there are no government subsidies.

"Crops for Food or Fuel: An Estimate of the Trade-off." Jerry A. Sharples (IED ESS USDA)
The production of an additional two billion gallons of ethanol from corn in the United States would increase the world price of grain about 6%. This result was obtained using a simple two-region world model of the grain-soybean market. Welfare implications are also obtained.

Commodity Futures (Anne Peck, Stanford University, presiding)

"Commodity Futures Price Theory for Semistorable Products." Steve Blank (California Polytechnic State University)
The objective of this paper is to specify and test a basic futures price theory for semistorable products. Both live and feeder cattle are tested as examples because it is expected that they will have some characteristics of both perfectly storable and perfectly nonstorable products. Feeder cattle proves to be more storable.

"An Econometric Model of Hedging, Speculation, and Volume in Commodity Futures." Ronald W. Ward and Robert M. Behr (University of Florida)
Hedging and speculative use of futures trading evolves out of the expected benefits from holding futures contracts. These trading positions are interrelated and are influenced by factors such as the levels of price risk, the degree of competition, the extent of government regulations, and alternative investment opportunities. An econometric model using pooled cross-sectional and time-series data on a three-equation system is used to explain hedging, speculation, and volume activity.

"Hedging Pork Products Using Live Hog Futures: A Feasibility Analysis." Marvin L. Hayenga and Dennis DiPietre (Iowa State University)
The feasibility of hedging ten wholesale pork products using the live-hog futures market was analyzed, and appropriate hedging relationships were estimated using 1970–79 data. Depending upon a firm's risk aversion, the live-hog futures market could be a useful risk management tool for meat processors and merchandisers dealing with pork products.

"Using Mechanical Trading Systems to Evaluate the Weak Form Efficiency of Futures Markets." Paul E. Peterson and Raymond M. Leuthold (University of Illinois)
A methodology is developed for using mechanical trading systems to evaluate the weak form efficiency of futures markets, including a method to statistically analyze trading results generated by these systems. These techniques are then used to test the weak form efficiency of the hog futures market from 1973 to 1977.

Editor's Note:
These Selected Papers have been filed with University Microfilms. That firm will provide microfilm, microfiche, or hard copy for a small fee. Write Xerox University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106.

Award-Winning Theses

Barnett, Richard Clay. "The Relationship between Domestic and International Liquidity and Nominal Agricultural Prices: A Time-Series Analysis." M.S. thesis, Purdue University, 1980.

No empirical evidence has been brought forth to test empirically whether recent increases in international liquidity have had any sizeable impact on the prices of many agricultural commodities traded internationally. Further, few studies have analyzed the effect these monetary variables have had on the ratio of agricultural prices to prices in the rest of the economy. This thesis represents an attempt to develop a theoretical model which explains the relationships between nominal and relative agricultural prices and money in a macroeconomic setting, as well as to test empirically these relationships using a variety of time-series methods.

The empirical evidence suggested that domestic and international monetary expansion had a significant effect on domestic agricultural and food prices in the United States and in the world in general during the 1970s. Monetary expansion also appears to have had an influence on the observed changes in the ratio of U.S. agricultural prices to nonagricultural prices during this period. The empirical evidence also suggested that money is causal to agricultural prices, with little or no feedback.

Rucker, Randal Ray. "The Dynamics of Montana Beef Cattle Inventories." M.S. thesis, Montana State University, 1980.

Models for estimating beef cattle herd sizes in Montana are estimated using a nonlinear least squares algorithm. The use of this algorithm allows the estimation of "nonstochastic difference equations" in which the stochastic component is purged from the lagged values of the dependent variable. Models are developed to explain the levels of total herd sizes as well as the levels of breeding herds. Explanatory variables in these models include the levels of hay production, beef to corn price ratio, and calf (or feeder steer) prices in preceding periods. Interpretations of the estimated distributed-lag patterns and of the nonstochastic forms of the difference equations are offered. The models estimated in this thesis appear to offer an improvement over previous attempts to explain and model beef cattle herd sizes.

Semprevio, Ralph Robert. "Estimation of Economic Structural Parameters and Multipliers under Conditions of Multicollinearity in Simultaneous Systems." M.S. thesis, Virginia Polytechnic Institute and State University, 1980.

The specific objectives of this research were fourfold: (*a*) to detect the extent of multicollinearity in simultaneous systems of equations; (*b*) to develop the Ridge Regression (RR) biased-estimation technique within the context of the two-stage least squares (2SLS) framework; (*c*) to compare the 2SLS procedure using RR integrated into the first- and/or second-stage estimations of the standard 2SLS procedure; and (*d*) to investigate the empirical applicability of using RR in the estimation of simultaneous systems of equations.

Three estimation procedures were compared: (*a*) the standard 2SLS procedure, (*b*) a technique involving RR in the first-stage estimation and ordinary least squares in the second stage (RO2SLS), and (*c*) a technique using RR in both the first- and second-stage estimations (RR2SLS).

The empirical applicability of using RR in the estimation of simultaneous systems was assessed through the estimation of a pork sector supply-demand model and a wheat sector-demand model. The estimation techniques were compared on the basis of total mean squared error (TMSE) and multiplier "sensibility."

The RR2SLS procedure is recommended as an extension of the 2SLS technique. This technique should be used when interpretation problems arise with respect to the 2SLS estimation results and prescribed multicollinearity indicators suggest a severe multicollinearity problem. The RO2SLS procedure is not recommended because, in this study, the estimation results were unimproved in comparison to those obtained with the 2SLS procedure.

Easter, Christopher Douglas. "Supply Response with Stochastic Technology and Prices in Australia's Rural Export Industries." Ph.D. thesis, University of California, Davis, 1980.

The primary purpose of this research was to explore the theoretical and empirical issues involved in the specification of a stochastic model of supply response in the Australian grazing industry. The second aim of this investigation was to estimate the responsiveness of the main rural export products to changes in output prices.

Unusual among developed countries, Australia still relies extensively on the rural sector for the generation of export revenue in the economy. A salient feature of those markets is their volatility, leading to price variability for Australian producers. Fluctuating seasonal conditions in the country impart to producers a second element of uncertainty—production risk. The stochastic programming model developed overcomes problems of

dimensionality or approximation, previously encountered in programming methodology, and successfully incorporates technological and price risk.

The model was

$$\text{maximise } \mathbf{E(p)'x} - \frac{\phi}{2}\mathbf{x}'\Sigma_p\mathbf{x},$$

such that

$$\mathbf{E(A)x} + [(\mathbf{x} \otimes \mathbf{I})'\Sigma_A(\mathbf{x} \otimes \mathbf{I})]^{\frac{1}{2}}\theta^{-1}(\alpha) \leq \mathbf{b},\ x \geq 0,$$

for $\mathbf{E(p)}$, a price expectations vector; $\mathbf{x}$, an activity level vector; ϕ, the Arrow-Pratt risk aversion coefficient; Σ_p, a price variance-covariance matrix; E(A), an input-output expectations matrix; Σ_A, a technology variance-covariance matrix; $\otimes$, the Kronecker product; I, an identity matrix conformable with $\mathbf{x}$; $\theta^{-1}(\alpha)$, a vector reflecting probabilities with which constraints are satisfied; and $\mathbf{b}$, a resources vector. Risky prices are represented in the maximand and stochastic technology introduced via chance constraints. Since deterministic equivalents of the chance constraints are nonlinear, it was not possible to solve the above model using conventional algorithms. Rather than approximating the solution using linearization procedures, iterative application of the asymmetric quadratic programming (AQP) algorithm was used.

The approach used met with considerable success. Examination of the convergency properties showed that the feasible solution set for the AQP problem contained the feasible solution set for the iterative model. Further, it was demonstrated that the existence of an optimal solution in the conventional AQP model was sufficient for there to exist an optimal solution for the iterative model with stochastic technology. Empirically, the success of the approach was reflected in the number of cycles of the model (5–8) required to achieve convergence.

In addition, performance functions were derived, graphical representation of price responses depicted, and own-price and cross-price elasticities of supply estimated for beef, wool, sheepmeats, and wheat. The vast information set generated by the model provides a useful framework within which the supply and revenue impacts of changes in domestic policy on the grazing industry can be assessed. Similarly, the model is useful in estimating output changes effected by policies implemented in importing nations.

Johnson, Frederick Ian. "An Analysis of Brazil's Sugar Program, 1953–1975." Ph.D. thesis, University of Minnesota, 1980.

Since 1931 Brazil has protected and regulated its domestic sugar industry. This study examines, in the context of a supply and demand analysis, how Brazil's sugar program has affected its domestic and foreign sugar market. The analysis covers the two key instruments of the sugar policy (the setting of prices and the restricting of sales); it considers separately the two main regions (the North-Northeast and the Center-South); and it encompasses primarily the period 1953–75.

The first step in the analysis is the construction of a model of production in which crop yields are stochastic. Several quota systems are considered, and in each case the producer response to the quota is inferred. It is shown that, in this stochastic framework, the quota can be treated as reduction in the effective price received by the farmer. The fraction by which the actual price is effectively reduced hinges upon the size of the quota and on the moments of the distribution of crop yields. Acknowledging the stochastic nature of the crop allows the estimation of the effective price and, in turn, the estimation of the free-market supply relation.

Supply and demand are then estimated. Employing these estimates, the impacts of the quotas are examined by simulating no-quota production, and the effect of price setting is examined by simulating production and consumption at world prices.

Stoll, John R. "The Valuation of Hunting-Related Amenities: A Conceptual and Empirical Approach." Ph.D. thesis, University of Kentucky, 1980.

A conceptual framework for the valuation of wildlife resource-related amenities is presented in this dissertation. The "new theory of demand," developed by Lancaster and other researchers in household production theory, are utilized in the development of this conceptual framework. Activity and existence values for resources are conceptualized. The end product is a framework which can be used in the collection of data, data analysis, and provision of information for wildlife resource management purposes. Hicksian measures of welfare change are also redefined within this framework, and a unique notation is introduced for their representation. These measures can be used to determine the impact upon households of changes in wildlife populations. Total value and compensated demand curves for the wildlife resource are defined.

An empirical application is presented and used to estimate values for elk hunting-related amenities in Wyoming. This application uses the iterative bidding form of contingent valuation techniques. In this case study, mean household willingness to pay (WTP) annually for the right to hunt elk is estimated to range from \$44.09 to \$126.04, depending upon the elk/encounter package. Previous methods of estimating models using iterative bidding results are substantially improved in this study. Theoretically relevant variables are identified using the developed conceptual framework: (*a*) variables defining the specific consumption package, (*b*) variables isolating differences in household consumption technology, and (*c*) variables indicative of differing tastes and preferences. The final estimated

model adopted for further use utilized income-categorized data and included variables which allow for variation in household consumption technology. This model resulted in an estimate of an income elasticity of bid equal to .369 which, in this model specification, is also equal to the price flexibility of income for elk encounters. A new method for handling "poor" respondents to iterative bidding formats is also discussed.

The estimated model is used to determine a total value curve for the right to hunt elk. From this total value curve, a compensated demand curve for elk encounters is derived. The estimated annual marginal value of an additional elk encounter is $3.65 when the household typically encounters five elk. The estimated annual total value of the right to hunt elk is $95.98 when six elk are typically encountered.

AAEA Business

Committee Reports

Report of the President

The state of the Association is sound. The past year is best characterized as one of consolidation and growth: growth because as of this date it appears that 1981 membership will be up from last year by 300 or more; consolidation because new editor James Houck, associate editors Frank Smith and Ben Senauer, secretary-treasurer Sydney James and business office director Wes Ebert are functioning well. Inflation coupled with transfers of editorship and the business office to new locations sharply raised costs, but, thanks in no small part to the Finance Committee headed by John Hopkin and to prudent investment of our financial assets by John Brake and his Investment Portfolio Subcommittee, the expected budget surplus for 1981 is $17,400 and no membership dues increase is necessary.

Sydney James and Wes Ebert have made substantial progress in computerizing membership files. This activity already provides payoffs in terms of readily accessible information for Association officers, the Membership Committee, and the *Handbook-Directory*. In these and a host of other potential uses, the payoffs come at a cost, not the least of which is the burden on membership of providing biographic data.

The Executive Board at its December 1980 meeting made the decision to use the Employment Registry form to collect biographic data because it was comprehensive in scope, available, and because the Department of Labor covered costs of forms and mailing. From the standpoint of the Illinois Job Service, the solicitation was a huge success, with approximately 2,200 persons entering the Employment Registry. From the standpoint of the *Handbook-Directory*, the solicitation fell short of success with approximately 1,800 members failing to complete the form. The Executive Board concluded that it is unwise to go to press under such circumstances, and Sydney James will send out an abbreviated form with membership dues notices for those who have not completed the required form. For those who have provided biographic data, a printout of information on file will be sent with the dues notices to provide opportunity for correction and update.

To minimize respondent burden in future years, basic biographic data will be printed on dues notices for updating and correction, and only new members will need to complete a comprehensive form. (I digress to note that the Executive Board requested that in the future, questionnaires mailed to AAEA members using membership lists provided by the secretary-treasurer be screened by the secretary-treasurer to avoid undue length or excessive coverage of membership.)

With the convenience offered by the electronic computer, a new *Handbook-Directory* can be printed as comprehensively as needed, with an abbreviated, low-cost directory of names, addresses, and telephone numbers printed annually if desired.

The Handbook-Directory Committee chaired by David Boyne has been a big help in deciding what data to include in the computerized membership file. That committee has been able to draw on the prior thinking and recommendations of the Operational Data Base Committee, of which Ken Farrell is chairman. The work of these committees is largely completed.

In reading reports of former presidents, I note the same thing impressed them that most impressed me—the complexity and breadth of participation of membership in the Association. I have appointed approximately 300 committee members and worked hard to involve a representative cross-section of the membership. This annual meeting, alone, features nearly 70 sessions, and each of these sessions averages several participants.

I have never worked with people more willing to give of themselves. Reasons for this willingness include recognition and another citation in ones vita, but much of the generous participation is selfless dedication to a strong sense of community in the Association. AAEA is a family. Maintaining that treasured sense of family is difficult and some members and groups get the feeling they are distant cousins—once or twice removed! Making these latter individuals and groups feel they are full participants whose needs are being met challenges the Executive Board. The Board is exploring alternative program formats and publication outlets for better ways to serve the diverse needs of the profession without sacrificing the needs of others. I report some of those activities below and offer additional comments in the September *AAEA Newsletter*.

I appointed ad hoc committees to examine the professional role and status of women, chaired by Ardelle Lundeen, and the role and status of blacks, chaired by Sidney Evans. The committee on women performed a comprehensive study reported in an invited paper session to be published in the December *Journal*. The committee on blacks is making progress and will provide a comprehensive report later. The Executive Board elevated the women's committee, based on their request for needed continuity, from ad hoc to special committee status.

The Professional Activities Committee (PAC) stimulates the Executive Board to devise ways better to serve the membership. PAC, under the leadership of Sam Cordes, brought before the Board several suggestions for improving the annual meet-

ing planning and program format. An ethical conduct policy proposed by PAC, for the Association committee members, directors, and officers was adopted by the Executive Board for inclusion in the bylaws.

In what can be a significant new development for the Association, the Executive Board asked Ed Schuh to appoint a committee to examine the opportunity for a new publication of the Association that will emphasize less esoteric research methodology and emphasize more effective communication of applied economics of interest to practitioners in teaching, extension, industry, administration, and research. Such a publication can be of great value in meeting the diverse interests of our members.

Following recommendations of the Professional Activities Committee, the Executive Board voted to cosponsor with Farm Foundation a conference, "Perspectives on Agricultural and Food Policy Research"; with USDA a conference on "The Economics of Food and Agricultural Trade"; and with the American Society of Agricultural Engineers two conferences, "Second International Livestock Environment Symposium" and "International Conference on Plant and Vegetable Oils."

The Membership Committee led by Gene Mathia used the campus recruiter approach this year to reach prospective and delinquent members. The system seems to have worked, based on the increase in membership. In future years, computerized membership files can give continuous feedback showing the success of each recruiter.

Thanks to special effort by the Resident Instruction Committee chaired by Duane Harris, the long-awaited and popular brochure "Careers in Agricultural Economics" is being printed in revised form this year. Contact Duane for copies, which can be purchased at cost. In part because of a new Student-Section administrative structure, student activities including presentation and judging of papers seems to be functioning smoothly this year. Students are the future of the profession, and the Board wishes to do what it can to encourage growth and activity of the Student Section.

Under leadership of Gary Seevers, the Industry Affairs Committee had a banner recruiting year, increasing membership 40%! They also sponsored the Industry Banquet and a symposium at the annual meeting.

The American Agricultural Economics Documentation Center in the USDA is gaining increasing recognition and use and is inputting 550—600 refenrences per month. The Board's confidence in the Center is apparent in $21,000 of Association funds allocated to provide a portion of the Center's cost, borne mainly by USDA.

With leadership from Dan Badger, chairman, the Literature Retrieval Committee continues to be one of our most active components. The committee sponsored a Literature Retrieval Workshop in May at the University of Missouri. Such workshops are critical to generate effective use of the automated literature search system, and more are being planned. Request a computerized search of your publications or a professional topic of your choosing—you will be impressed!

The work of the Postwar Literature Review Committee is winding down. Chairman Emerson Babb indicates final volume 4 will be published in early 1982. A special offer of all four volumes will be made to the AAEA membership.

J. B. Wyckoff heads a committee to provide travel grants to the conference of the International Association of Agricultural Economists meeting in Jakarta, Indonesia next year. The Executive Board allocated $7,500 of AAEA funds to support the grants.

Anticipating that funding of agricultural economics (including data systems) would be the major concern of Association members this year, I appointed a blue ribbon ad hoc committee last fall with Bud Stanton as chairman to explore this issue in depth and report to the Association. Some interesting results are presented in a general session Wednesday morning, to be published in the December *AJAE*.

The Association is in an excellent position to express its views on matters of funding, data systems, and other concerns through membership in the Federation of Scientific Agricultural Societies (Tweeten and Emery Castle representing AAEA), Federal Statistics Users' Conference (Norman Coats, representative), Committee of Professional Associations on Federal Statistics (Bruce Gardner and Glenn Nelson, representatives) and by liaison with the Census Advisory Committee on Agricultural Statistics (Bruce Gardner, representative) and National Bureau of Economic Research (Ed Schuh, representative).

I am deeply grateful to the Executive Board, committee chairpersons, and to all of you for giving me one of the most rewarding year's of my life. It is an exhilarating experience to work with such fine people. You provide a model of competence, dedication, and cooperation that I will always cherish.

Luther Tweeten, President

Report of the Secretary-Treasurer

The AAEA membership for 1980 was 5,845 (table 1). There was a reduction in virtually every category. The circumstances relating to the change in the secretary-treasurer's office can be blamed for this reduction which I hope will be temporary.

The number of members who paid their dues for 1981 on or before 1 April, and therefore received a ballot to vote, decreased by 102, and 197 fewer ballots were returned as compared to last year (table 2).

The 1980 operating statement for AAEA showed

Table 1. Number of Members and Subscribers, 1980, with Comparisons

Category	1978	1979	1980
Institutional members	32	34	32
Regular members			
U.S.	2,884	2,865	2,691
Foreign	811	870	555
Senior members[a]	137	140	121
Junior members			
U.S.	462	500	493
Foreign	47	52	50
Corresponding[b]			
U.S.	0	0	0
Foreign	0	0	0
Libraries & business			
U.S.	670	739	721
Foreign	1,271	1,335	1,179
Exchange	3	3	3
Total	6,317	6,538	5,845

[a] New, category established in 1976.
[b] Category combined with regular members in 1976.

a drastic change as compared with 1979 and previous years (table 3). It showed a negative balance of $6,502.85. Caution should be noted constantly in analyzing operating statements. Extraordinary items often convey normal activity. For 1980, we had $73,096.42 less income, including $14,199.38 less in dues and subscriptions, $19,624.50 less in page charges and reprints, and $12,119.50 less in *Journal* sales; but we had $13,116.50 increase in investment earnings, largely because of our bonds

Table 2. Number of Members Paid by 1 April, Ballots Mailed and Returned, with Comparisons

Category	1979	1980	1981
U.S. members	2,955	3,192	3,101
Canadian members	154	195	180
Foreign members	535	505	509
Total ballots mailed	3,644	3,892	3,790
Total ballots returned	1,804	1,871	1,674

and money mart funds. The miscellaneous income was $3,250 collected for industry banquet and $24.85 from exchange fees.

At the same time our income decreased, our expenses increased by $48,005.14. We paid $98,400.21 for five issues in 1980 as compared to $113,359.12 for seven issues in 1979, a reduced outlay of nearly $15,000. Most of the expense items ran about as in the past, except for three major categories: (*a*) editorial support, (*b*) subsidy to University of Minnesota Press, and (*c*) miscellaneous expense, of which two-thirds of the increase were due to moving the office. Not all of the moving allocation was spent.

The editorial support increased by $20,870 to $45,370. The practice has been to pay one-half of a year's support to the new institution assuming the editorship. The documentation center allocation was increased by $2,000 to $17,000. The University of Minnesota Press was paid a $10,000 subsidy for publishing volume 3, which, along with the remit-

Table 3. 1980 AAEA Operating Statement, with Comparisons

Item	1978 Actual	1979 Actual	1980 Actual
	($)		
Income:			
Dues and subscriptions:			
Regular members	100,103.27	90,203.27	78,658.37
Senior members	825.00	687.50	504.00
Junior members	8,116.54	9,958.64	9,491.96
Subscriptions	56,241.25	74,516.28	72,666.98
Corresponding	0	0	0
Institutional	3,200.00	3,400.00	3,245.00
Lit. retrieval	0	0	0
Journal publications:			
Journal sales	7,815.89	16,834.07	4,714.57
Page charges and reprints	36,022.73	52,240.75	32,616.25
Advertisements (*Journal*)	1,195.82	1,035.00	1,265.50
Newsletter	0	2,570.00	4,234.50
Royalties	4,260.38	337.13	383.29
Other	0	0	0
Postwar Literature Review sales	13,727.50	6,153.59	1,222.16
Investments	16,777.52	28,788.95	41,905.45
Annual meeting	2,000.00	8,647.34	1,780.74
Address labels	1,140.88	1,890.56	2,803.56
Miscellaneous	2,643.39	5,822.37	3,274.85
San Diego	0	0	0
Gain (loss) stock or bond sale	21,120.54	29,050.73	270.58
Total	275,190.71	332,136.18	259,037.76

Table 3. 1980 AAEA Operating Statement, with Comparisons (Continued)

Item	1978 Actual	1979 Actual	1980 Actual
	($)		
Expenses:			
Journal:			
Printing	71,543.25[a]	113,359.12[b]	98,400.21[c]
Editorial support	22,500.00	24,500.00	45,370.00
Printing reprints	5,313.22	7,649.88	7,469.13
Purchase *Journals*	93.08	78.00	4,768.85
Newsletter	670.00	9,455.32	7,560.28
Lit. Retrieval/Doc. Center	15,000.00	15,000.00	17,000.00
Postwar Lit. Review	14,754.70	3,598.50	10,597.50
AAEA (Int. Conf.) grant	0	0	0
Handbook-Directory	0	0	0
Awards	1,108.68	1,767.00	2,364.72
Student activities	0	0	0
General operations:			
Postage and phone	4,140.97	4,359.65	5,181.17
Off. supplies and printing	8,586.15	6,038.81	7,019.97
Annual meeting	5,250.92	1,981.73	4,134.42
Committees	488.29	61.22	1,016.66
Bonds	115.00	115.00	0
Audit	500.00	500.00	500.00
Secretary-Treasurer assistant	17,368.04	17,368.98	18,151.56
Secretary-Treasurer honorarium	5,000.00	5,000.00	5,000.00
Miscellaneous	13,383.79	6,702.26	31,006.14
San Diego	0	0	0
Total expenses	186,296.09	217,535.47	265,540.61
Balance	88,894.62	114,600.71	−6,502.85

[a] For four (4) issues of the *Journal*.
[b] For seven (7) issues, including Parts 1 and 2 of November 1979.
[c] For five (5) issues of the *Journal*.

tance of book sales, made this item $10,597.50. Almost all of the increase in the purchase of journals went to purchase two complete sets, on which we should double our money. The increase in annual meeting cost was largely because AAEA assumed the loss incurred at the University of Illinois in 1980.

The $31,006.14 miscellaneous expense category contained the following items: $800 for contract labor; $407.00 refunds due to overpaying; $15 345.00 to Iowa State, which included $345 paid for labor in packing and loading ($15,000 to ISU); $40 00 for post office permit; $69.15 for repairs; $2,000.00 to COPFAS; $7,052.98 for evaluation report (to be offset by a grant); $300 dues to Federal Statistics Users Committee; $3,059.34 for industry affairs banquet (offset by $3,350 income): $955.27 for liability insurance for directors; $899.40 for CPT maintenance contract; $29.00 for CPT fire insurance; and $50.00 for copyright of the issues printed.

Two very important facts stand out in the man-

Table 4. USDL Operating Statement, 31 December 1980, with Comparisons

Item	1978	1979	1980
	($)		
Beginning balance	−15,002.57	−19,741.80	1,238.18
Amount received	0	23,535.00	0
Expenses	4,739.23	2,555.02	1,288.72
Ending balance	−19,741.80	1,238.18	−50.54

Table 5. Income-Expense Statement of Editor's Office, 1980

Item	University of Missouri 1977–80 (Total)	University of Minnesota 1980
	($)	
Income:		
AAEA appropriation		
Journal	85,000.00	16,370.00
Newsletter	2,000.00	0
Total income	87,000.00	16,370.00
Expenses:		
Salaries and fringes of assistant editor and secretary	73,311.17	13,969.82
Postage and telephone	8,832.85	2,103.37
Supplies	1,129.59	235.96
Refunded	4,021.59	0
Total expenses	87,295.20	16,309.15
Balance	−295.20	60.85

Table 6. Combined Balance Sheet, 31 December 1980, with Comparisons

Item	1978	1979	1980
	($)		
Assets:			
Cash-bank	12,968.72	619.19	18,049.73
Cash-bank (USDL)	0	1,238.18	0
Cash-UK	6,740.76	1,358.77	4,542.29
Cash-broker	4,651.28	1,076.00	1,823.99
Accounts receivable	0	35,555.95	35,555.95
Investments:			
Certificates of deposit	85,046.17	1,091.52	1,150.54
Ready assets	26,167.55	166,333.54	94,146.60
Stocks (at cost)	129,366.50	164,985.54	172,508.50
Bonds (at cost)	49,631.76	89,633.76	74,666.76
Approximate market value (stocks)	178,233.375	212,667.00	283,957.125
Approximate market value (bonds)	46,092.40	84,918.80	69,723.00
Total assets (at market value)	359,900.255	504,858.95	508,949.255
Total assets (at cost)	314,573.74	461,892.45	402,444.36
Liabilities:			
USDL unspent funds	(19,741.80)	1,238.18	(50.54)
Prepaid dues	66,177.50	78,032.62	26,376.10
Accounts payable	23,116.10	23,000.00	23,000.00
Net worth (at cost)	245,020.94	359,621.65	353,118.80
Net worth (at market value)	290,348.455	402,588.15	459,623.665
Total liabilities (at market value)	359,900.25	504,858.95	508,949.225
Total liabilities (at cost)	314,572.74	461,892.45	402,244.36

agement of the AAEA activities. The AAEA can never relax on its efforts to collect dues, subscriptions, page charges, etc., and to enhance other income-producing activities, such as sales journals, advertising, address labels, etc. Second, the AAEA must carefully watch and control its expenditures. It is easy to finance a lot of good activities but are they worth the cost? Unless these things are carefully monitored, dues must increase substantially. It may be too costly to the profession to know the price elasticity of demand for AAEA services.

The National Registry projects started in 1973 with a grant from the U.S. Department of Labor. It was renewed or modified in June 1980 for the thirteenth time and was due to expire again 30 June 1981. We ended the year with a negative balance of $50.54 (table 4). Upon completion of the activities, including the final report, additional funds from the $10,404 held back by USDL should be forthcoming to cover the actual costs incurred.

In accordance with the policy established in 1973, the editor provided an income-expense statement for editorial support for 1980. It is incorporated as a part of this report (table 5). Since 1980 was a year of change of editors, Rhodes gave a report for his tenure, 1977–80, while Houck's report covered only the 1980 transition.

The balance sheet for 1980 showed a slight decrease ($6,502.85) in net worth, as compared to a $114,600.71 increase in 1979 (table 6). The AAEA assets are carried on the books at cost. However, market values are shown for your information. A problem has developed over the past two years with accounts receivable. It appears that our debtors are not in any big hurry to pay the AAEA. Perhaps we should consider adding a 1.5% monthly charge on all accounts thirty days past due.

This is my eleventh and last annual report. The Association is still healthy, viable, and active. With inflation and pressures for greater financial support for more and more activities, our fiscal strength can be sapped rather quickly. It has been a pleasure and certainly a great experience to have been your secretary-treasurer for the past eleven years.

John C. Redman, secretary-treasurer
31 December 1980

Investment Report

The portfolio subcommittee of the Finance Committee made a few changes in our portfolio during 1980. Our investments produced an income of $41,905.45 from all sources (table 1). We kept a large proportion in money mart funds, and the high interest rates were very kind to us. The $41,905.45 return was a 45.6% increase over 1979 and 149.8% over 1978. All assets, carried on the books at a cost of $342,472.40, had a market value of $448,977.26 at the end of the year. A large part of our portfolio was near cash. The detail on our stocks—the issue, amount, cost, dividends, market value, sales and purchases—is shown in table 2, and the detail on

Table 1. AAEA Summary of Investments, Year Ending 31 December 1980

	Income	Value	
	1 Jan.–31 Dec. 1980	Cost	Market
	($)		
Stocks			
On hand, 1 Jan. 1980		164,985.54	212,667.00
On hand, 31 Dec. 1980		172,508.50	283,957.25
Dividends	16,014.04		
Bonds			
On hand, 1 Jan. 1980		89,633.76	84,918.80
On hand, 31 Dec. 1980		74,666.76	69,723.00
Interest	8,225.33		
Miscellaneous[a]			
Money Mart Asset trust, 31 Dec. 1980	17,607.06	94,146.60	94,146.60
Savings account, 31 Dec. 1980	59.02	1,150.54	1,150.54
Total (31 Dec.)	41,905.45	342,472.40	448,977.265

[a] Amount fluctuates.

Table 2. AAEA Stocks, 31 December 1980

Company	Number of Shares	Original Cost	Dividends 1980	Market Value 31 Dec. 1979	Market Value 31 Dec. 1980
		($)			
American Cyanamid	0[a]		600.00	17,000.00	0
American Home Products	200	5,636.05	340.00	5,450.00	5,625.00
American T&T	603	28,355.11	3,015.00	31,431.375	28,868.625
Borden	300	4,309.09	564.00	7,162.50	7,725.00
Browning Ferris	600[b]	10,459.09	210.00	0	14,100.00
Chase Manhattan	93	1,115.09	260.40	3,529.125	4,475.625
Commonwealth Edison	232	7,467.14	603.20	4,640.00	4,205.00
Cont. Corp.	400	10,161.33	880.00	10,650.00	9,650.00
Cont. Group	225	4,315.38	540.00	6,496.875	7,340.625
Diamond Shamrock	400[c]	12,137.30	328.00	0	14,150.00
Exxon	306	10,325.36	1,652.40	16,868.25	24,671.25
Foremost-McKesson	400	10,161.33	756.00	10,300.00	12,600.00
Girard	400	10,767.96	788.00	10,200.00	9,500.00
Goodyear	500	16,692.50	650.00	6,437.50	8,000.00
Jewell	150	3,875.94	279.00	3,937.50	5,137.50
MMM	200	10,626.79	560.00	10,050.00	11,800.00
NICOR	0[d]	—	13.32	231.875	0
Santa Fe Indust.	300	10,299.00	780.00	15,600.00	30,750.00
Sears Roebuck	608	1,845.38	814.72	10,944.00	9,196.00
Southern Pacific	300	10,280.32	780.00	10,125.00	12,262.50
Std. Oil-Indiana	800[e]	3,678.34	1,600.00	31,550.00	63,900.00
Total		172,508.50	16,014.14	212,667.00	283,957.125

[a] Sold 500 shares @ 30⅝ = $15,070.67 (net on 11-20-80). Cost $15,073.43. Loss $2.76.
[b] Bought 600 shares @ 17⅛ = $10,459.09 on 6-10-80.
[c] Bought 400 shares @ 29⅞ = $12,137.30 on 6-10-80.
[d] Sold 7 shares @ 43 = $275.34 (net) on 12-4-80. Cost 0. Gain $275.34.
[e] Split 2 for 1 on 6-6-80.

Table 3. AAEA Bonds, 31 December 1980

Bond	Rate	Matures	Cost	Interest	Market Value
			($)		
CIT Financial	7-5/8	1981	19,628.61	1,525.00	18,350.00
Commercial Credit	8-7/8	1986	10,164.79	887.50	7,900.00
Federal Farm Credit[a]	14.35	1980	—	4,352.83	—
Federal Land Bank	7.3	1982	19,838.36	1,460.00	18,448.00
Federal Farm Credit	14.90	1981	25,035.00	0	25,025.00
Total			74,666.76	8,225.33	69,723.00

[a] Matured on 8-8-80 at face value of $40,000, cost $40,002.00, loss $2.00.

our bonds is shown in table 3. I used the money mart fund heavily to earn a high rate of return on funds not needed for immediate payment of bills.

The portfolio subcommittee of 1980 (John Brake, Richard Feltner, and myself) tried to serve you well. With 1980, my eleven years as either chairman or member of the investment (portfolio) committee came to a close. I learned much.

John C. Redman
31 December 1980

Report of the Finance Committee

This annual report covers the activities of the Finance Committee for the period August 1980–July 1981. The primary activities during this period were to monitor AAEA income and expenses with special reference to issues relating to transferring the secretary-treasurer's office from the University of Kentucky to Iowa State University, provide guidance to the investment subcommittee, and prepare the 1982 budget. Members of the committee are

Table 1. AAEA Actual Expenses and Budgets, July 1981

Item	1980 Actual	1980 Budget	1981 Budget (revised)	1982 Budget
	($)			
Journal				
Editor transfer	0	12,000	0	0
Printing	98,400	90,100	87,000	88,000
Editorial support	45,370	28,000	41,000	41,900
Printing reprints	7,469	7,000	10,000	10,000
Purchase journals	4,768	0	0	0
Postage & storage	0	15,000	18,000	20,000
Subtotal	156,007	152,100	156,000	159,900
Newsletter				
Printing		6,000	7,800	7,400
Postage		3,300	5,200	5,800
Editorial		1,100	2,600	2,600
Subtotal	7,560	10,400	15,600	15,800
Literature Retrieval Document Center	17,000	17,000	19,000	19,000
Postwar Literature Review	10,597	8,000	7,000	8,000
International Conference Travel Grant	0	0	0	5,000
Handbook-Directory	0	0	5,000	35,000
Awards	2,364	1,500	2,500	2,500
Registry[a]		500	500	500
Annual meeting	4,134	3,000	2,500	3,000
Committees	1,016	1,500	1,500	1,500
COPFAS, FSAS, etc.[b]	2,000	2,000	2,000	3,000
Subtotal	37,111	33,500	40,000	77,500
Business office				
Salaries	23,152[c]	25,000		
Director			11,000	11,800
Association director			10,500	11,300
Secretarial, clerical			23,000	20,000
Data processing			7,000	5,000
Printing and postage			11,000	12,000
Telephone	12,200[d]	15,000[d]	1,000	1,200
Office supplies and support			5,000	5,000
Bonds, insurance, and audit	500	750	2,000	2,000
Equipment, purchase, service	0	0	5,000	2,000
Miscellaneous	29,006	18,800	5,000	5,000
Subtotal	64,858	59,550	80,500	75,300
Total expenses	265,536	255,550	292,100	328,500

[a] Previous budgets and operating statements did not separate the Registry.
[b] Committee of Professional Associations of Federal Statistics.
[c] Includes director, Association director, and secretary.
[d] Includes printing, telephone, office supplies, and support.

Table 2. AAEA Actual Income and Budgets, July 1981

Item	1980 Actual	1980 Budget	1981 Budget (revised)	1982 Budget
	($)			
Dues and subscriptions				
Regular members	78,658	92,500	90,000	94,000
Senior members	504	1,250	2,500	2,500
Junior members	9,491	6,250	7,500	8,500
Subscriptions	72,667	61,000	65,000	70,000
Institutional	3,245	3,500	3,500	4,000
Subtotal	164,565	164,500	168,500	179,000
Journal publication				
Journal sales	4,715	8,500	5,000	5,000
Page charges and reprints	32,616	36,000	50,000	50,000
Advertisements	1,266	1,000	1,000	1,000
Royalties	383	1,000	500	500
Newsletter advertising	4,235	4,200	3,500	4,200
Subtotal	43,215	50,700	60,000	60,700
Postwar Literature Review	1,222	0	8,000	10,000
Investments	41,905	23,000	35,000	40,000
Annual meeting	1,780	3,000	1,500	1,500
Address labels	2,803	1,500	1,500	1,500
Miscellaneous	3,274	300	25,000[a]	4,000
San Diego	0	0	0	0
Gain (loss) stock sales	273	0	10,000	0
Subtotal	51,257	27,800	81,000	57,000
Total income	259,037	243,000	309,500	296,700
Balance (income minus expenses)	−6,499	−12,500	17,400	−31,800

[a] Collections on accounts receivable—primarily from ESS USDA for foods conference and operational data base study.

John A. Hopkin, chairman (Texas A&M University), Richard Heifner (AMS/USDA), John R. Brake (Cornell University), Richard Feltner (Louisville, KY), John C. Redman (University of Kentucky); and Sydney James (Iowa State University). The committee has not met formally during the year. However, they have been in communication via correspondence and telephone.

AAEA Financial Condition

Because the secretary-treasurer's office was in the process of transfer during the period November-January, the Finance Committee was unable to submit a coordinated report of Association income and expenses at the 1980 Board meeting in December. However, completed statements of expenses and income for 1980 have been included as tables 1 and 2 of this report. Additionally, the year-end balance sheet has been reviewed and is included in the secretary-treasurer's report. These tables indicate that the Association is in a healthy financial condition. Although expenses exceeded income by about $6,500 to 1980, this net loss was somewhat less than projected. Three items primarily account for the increased expenses from previous years: a $12,000 cost for transferring the editorial office, a $15,000 allocation for transferring the secretary-treasurer's office and the jump in the cost for editorial support from $28,000 to $45,370. The net worth of the Association (at market value of assets) on 31 December 1980 reached an all-time high of about $47,000.

Revised budget projections for 1981 are that income will exceed expenditures by $17,400. This projection recognizes increased earnings and capital gains on investments and anticipated collection of $25,000 in accounts receivable, as well as a strong reversal of a downtrend in membership dues experienced in 1980. However, because of costs associated with the printing of the handbook-directory, a net loss of $31,800 is projected for 1982.

In conclusion, the Association is in a strong financial position, with an investment portfolio of 1.3 times its projected annual operating expenses. Therefore, the Finance Committee recommends that there be no increase in membership dues at this time.

Financial Transfer of Association Books

As of 28 July 1981, the books of the association are in the hands of John Redman at Lexington, Kentucky. Immediately on completion of an audit by

the IRS of the 1979 accounts, all record books are to be transferred to Iowa State University, and the accounts at the University of Kentucky will be closed, except for a balance of $100 which will remain at the University of Kentucky to cover costs of forwarding *Journals* and other non-first-class mail that should be forwarded.

Special thanks are due to both Dr. John Redman, University of Kentucky and to Dr. Sydney James and Wesley Ebert, Iowa State University, for going the extra mile in effecting the transfer of the secretary-treasurer's office with a minimum of strain and disruption to the Association.

John A. Hopkin, chairperson

Report of Tellers Committee

Ballots received from AAEA secretary-treasurer were counted in accordance with the bylaws of the Association to preserve secrecy. A total of 1,674 ballots were cast. Leo Polopolus is the new president-elect. New directors are J. B. Wyckoff and Joseph Havlicek, Jr.

We suggest that the board of directors of AAEA investigate the possibility of using pencil-marked computer cards as the response mechanism for next year's election.

Roger A. Dahlgran
Roger Ginder

Report of the Editor

The transfer of the editorial office from the University of Missouri to the University of Minnesota proceeded smoothly. It began 1 May 1980. Much of the credit for this easy transition goes to former editor V. James Rhodes and former *AJAE* secretary, Donna Taylor. They were most helpful and cooperative at every step. Having the *Journal*'s assistant editor, Martha Luzader, continue in that position by moving to St. Paul was another major factor easing the process.

The Minnesota editorial office is well-served by its new secretary, Mary Strait. Associate editors Benjamin Senauer and Frank Smith have assumed their duties with vigor and professional skill. All of us in the editorial office are pleased with the encouragement and general support provided by the Department of Agricultural and Applied Economics and the University of Minnesota.

AJAE Operations

In the 12-month period 1 July 1980 to 30 June 1981, 342 new manuscript submissions were received. This appears to be a new record, up 3% from the 333 received during the same period in 1979/80. New submissions arrive at a steady rate of 26–30 per month, with no noticeable seasonality.

In 1981, the *Journal* will publish 96 refereed articles, notes, and comments in four quarterly issues and 70 papers and discussions in the May and December proceedings issues. In addition, Ronald Schrimper, the new book review editor at North Carolina State University, will provide 33 new book reviews. All of this will cover about 1,150 *Journal* pages.

At any one time, about 80–100 *Journal* manuscripts are out for review, continually engaging 150–200 referees, many of whom are not AAEA members. We are amazed at the cooperation, insight, professional commitment, and promptness of almost all *AJAE* reviewers. To each of the 535 listed in the accompanying table, we extend sincere appreciation. We also acknowledge with thanks the individual and collective contributions of the *Journal*'s 16-member Editorial Council whose names appear on the inside front cover of each issue.

Our relations with Heffernan Press have been most satisfactory this year. Heffernan has cooperated well in the editorial transfer, continuing to provide a high quality product and good service.

AAEA Newsletter

We will maintain the bimonthly *Newsletter* schedule. Because there is usually plenty of material to be published, the 16-page format will continue to be our standard. Currently, the *Newsletter* is being printed and mailed in a timely way by Bolger Printing Company of St. Paul, MN, using computerized mailing labels provided by the AAEA secretary-treasurer's office.

Former editor Rhodes deserves much credit and the membership's gratitude for bringing the *Newsletter* to life in 1979. It was clearly an immediate success, filling an obvious gap in the Association's service to its members. We intend to continue in the tradition he established.

Secretary-Treasurer's Office

The transfer of the secretary-treasurer's office from the University of Kentucky to Iowa State University could have been troublesome for *Journal* and *Newsletter* operations. However, the move was handled so skillfully by John Redman, Sydney James, and their respective colleagues that scarcely a beat was missed in providing financial support, mailing labels, and other services to the *Journal* and *Newsletter*.

We look forward to another year of publishing a strong, broad-gauged *Journal* and a lively, useful *Newsletter*.

James P. Houck, editor

Table 1. Reviewers, 1980–81

Martin E. Abel	Steven T. Buccola	Arnold Faden	Dale Heien
Michael Abkin	Bruce Bullock	Sally Fairfax	Richard G. Heifner
Dale W. Adams	Oscar R. Burt	Walter P. Falcon	John Helmberger
Roy D. Adams	Rueben C. Buse	Gershon Feder	Peter Helmberger
Irma Adelman	Walter R. Butcher	David Felix	Robert W. Herdt
P. K. Aiyasami	Boyd M. Buxton	Barry C. Field	William M. Herr
Philip G. Allen	Peter Calkins	Darrell F. Fienup	Roger Hexem
Marilyn A. Altobello	Wilfred Candler	Robert M. Finley	L. Dean Hiebert
Donald E. Anderson	Oral Capps, Jr.	Robert S. Firch	Tom A. Hieronymus
Lee G. Anderson	Thomas Carlin	Brian S. Fisher	Lowell D. Hill
Robert W. Anderson	Gerald A. Carlson	Lee Fletcher	R. Carter Hill
Jeffrey Apland	Emery N. Castle	Stanley M. Fletcher	Fred J. Hitzhusen
Ahmed A. Araji	Richard E. Caves	Roger Fox	Irving Hoch
Robert Aukes	Robert Chambers	J. W. Freebairn	George Hoffman
Harry Ayer	Jean-Paul Chavas	Donald Freebairn	Duncan M. Holthausen, Jr.
Carlos Baanante	Steven N. S. Cheung	Ben C. French	Dale M. Hoover
Emerson M. Babb	Peter K. Clark	Varden Fuller	John A. Hopkin
Elizabeth E. Bailey	Richard Clark	Steven W. Fuller	Anwarul Hoque
Robert Bain	Edward J. Clay	Wayne A. Fuller	Gerald L. Horner
Chester B. Baker	Elizabeth Clayton	Gene Futrell	Robert M. House
Timothy G. Baker	Willard W. Cochrane	Paul Gallagher	Charles W. Howe
Malcolm D. Bale	L. R. Cohen	Philip Garcia	Barbara Huddleston
Pranab K. Bardhan	Keith J. Collins	B. Delworth Gardner	Darrell L. Hueth
Bruce B. Bare	Robert A. Collins	Bruce Gardner	Wallace Huffman
Randolph Barker	Howard E. Conklin	Leon Garoyan	Robert Hunt
Paul W. Barkley	Michael L. Cook	John M. Gates	Verner G. Hurt
Howard N. Barnum	Thomas F. Cooley	Christopher Gerrard	Leroy J. Hushak
Richard L. Barrows	Dennis C. Cory	John Geweke	Risto Ihamuotila
Peter J. Barry	Eric Crawford	Leon Geyer	Cathy Jabara
Sandra Batie	Richard J. Crom	Ray A. Goldberg	Frank G. Jarrett
C. Phillip Baumel	Pierre Crosson	Frank M. Goode	Lovell S. Jarvis
D. Lee Bawden	Reynold P. Dahl	Carl H. Gotsch	Mark S. Jelavich
William E. Becker	Roger A. Dahlgran	Kenneth R. Gray	Harald Jensen
Martin J. Beckman	Dana G. Dalrymple	Roger Gray	Helen Jensen
James Beierlein	Leon E. Danielson	Richard Green	E. V. Jesse
Frederick W. Bell	Lee M. Day	Robert Green	D. Gale Johnson
David A. Belsey	A. S. Deaton	Hans Gregersen	Glenn L. Johnson
Fred Benson	David Debertin	Wade Gregory	Marc A. Johnson
Peter Berck	John De Boer	Steven C. Griffin	O. E. G. Johnson
E. R. Berndt	Christopher Delgado	Wade L. Griffin	Paul R. Johnson
R. L. Berry	Johannes Delphendahl	William E. Griffiths	Bruce F. Johnston
David A. Bessler	Anil B. Deolalikar	Zvi Griliches	Robert W. Jolly
Arlo Biere	John L. Dillon	John Groenewegen	Bob F. Jones
Christopher Bingham	Bruce Dixon	Ernest W. Grove	Tim Josling
James Binkley	Craig L. Dobbins	Russell L. Gum	Richard E. Just
Hans P. Binswanger	William D. Dobson	Duane Hacklander	K. Rao Kadiyala
Richard C. Bishop	Gerald A. Doeksen	Thomas F. Hady	Kandice H. Kahl
Leroy Blakeslee	Otto C. Doering, III	Lana L. Hall	Toshiyuki Kako
David Blandford	John P. Doll	Milton C. Hallberg	Arie Kapteyn
Betty J. Blecha	Graham F. Donaldson	Jerome Hammond	Ronald D. Kay
Nancy E. Bockstael	Peter Dorner	Charles Handy	David Kenyon
Michael D. Boehlje	Folke Dovring	Michael Hanemann	Mahmood H. Khan
William G. Boggess	Richard W. Dunford	David E. Hansen	W. E. Kibler
Richard N. Boisvert	James Easley	Ian Hardie	Gordon A. King
James T. Bonnen	K. William Easter	Neil Harl	Richard A. King
Garnett Bradford	David Eastwood	David Harrington	Robert P. King
John R. Brake	Bobby Eddleman	Duane G. Harris	Jean Kinsey
J. A. Brandt	Kenneth E. Egertson	Ed Harshbarger	Yoav Kislev
Maury E. Bredahl	Vernon R. Eidman	Zuhair A. Hassan	Robert W. Klepper
Harold F. Breimyer	Edwin J. Elton	James B. Hassler	Jack L. Knetsch
Michael Brewer	Peter M. Emerson	Arthur Havenner	Glenn A. Knowles
Vernon M. Briggs	Gerald Engelman	Joseph Havlicek, Jr.	T. A. Kofi
Lars G. Brink	Milton H. Erickson	Yujiro Hayami	William E. Kost
Daniel W. Bromley	David Ervin	Marvin L. Hayenga	Randall Kramer
William G. Brown	Edmund A. Estes	Peter Hazell	Wesley R. Kriebel
Oswald H. Brownlee	Sidney Evans	Earl O. Heady	John E. Kushman
W. Keith Bryant	Robert Evenson	James Heckman	Walter C. Labys

Table 1. Continued

Jean-Jacques Laffont	Michael Nelson	James Roumasset	Lester D. Taylor
R. McFall Lamm	Paul E. Nelson	Jeffrey S. Royer	D. E. Teeguarden
David B. Land	James Nix	Clifford S. Russell	Lloyd Teigen
Max R. Langham	George Norton	Vernon W. Ruttan	George Temple
Mack Leath	Roger Norton	James G. Ryan	Kenneth Thomas
Ivan Lee	Virgil J. Norton	Timothy J. Ryan	Jerry Thompson
Linda K. Lee	Andrew Novakovic	Charles Safley	Robert L. Thompson
Lung-Fei Lee	Frank O'Connor	Larry Salathe	Stanley R. Thompson
Harvey Leibenstein	Ronald Oliveira	William Sander	Kenneth J. Thomson
Frederick L. Leistritz	Mancur Olson, Jr.	Fred Sanderson	Eric Thor
Milburn L. Lerohl	Peter Oram	Alexander Sarris	Thomas Tice
William Lesser	Don Paarlberg	Kazuo Sato	C. Peter Timmer
Raymond M. Leuthold	Philip L. Paarlberg	Pasquale Scandizzo	Richard Todd
Lawrence Libby	William M. Park	Lyle Schertz	William Tomek
William W. Lin	E. C. Pasour, Jr.	Fritz Scheuren	Randall Torgerson
Robert Lindner	Allen Paul	Gerald E. Schluter	W. Bruce Traill
Robert Litterman	Arnold Paulsen	Andrew Schmitz	James Trapp
Samuel H. Logan	Douglas K. Pearce	John Schnittker	Richard W. Tresch
Ramon Lopez	Anne Peck	Richard Schoney	Ronald Trosper
C. A. Knox Lovell	J. B. Penn	David M. Schoonover	Stephen Turnovsky
Yao-Chi Lu	John B. Penson, Jr.	Andrew Schotter	Luther G. Tweeten
Clifton Luttrell	Richard K. Perrin	Lee F. Schrader	Fred H. Tyner
Alex McCalla	Martin K. Perry	Ronald A. Schrimper	Wallace E. Tyner
Bruce McCarl	Charles H. Peterson	G. Edward Schuh	Timothy J. Tyrrell
Kenneth E. McConnell	Willis Peterson	Gerald Schwab	Joseph N. Uhl
R. J. McConnen	Todd Petzel	Grant M. Scobie	Nelson J. Updaw
J. A. McQuown	Louis Phlips	John T. Scott	Henry Vaux
Dennis Maki	Tom R. Pierson	David Seckler	Hrishikesh D. Vinod
Wilbur R. Maki	Per Pinstrup-Andersen	Wesley Seitz	Peter Vitaliano
G. Wayne Malone	James Plaxico	Roger Selley	J. D. Von Pischke
Alden C. Manchester	Peter Pollak	Carl E. Shafer	John Waelti
Lester Manderscheid	Leo Polopolus	James D. Shaffer	Tom Waggoner
J. S. Mann	Giulio Pontecorvo	Haim Shalit	David J. Walker
Marilyn Manser	Rulon D. Pope	Jerry A. Sharples	Larry J. Walker
Lockwood Marine	Lee F. Preston	Robert J. Shiller	Odell Walker
Bruce Marion	David Price	C. Richard Shumway	Ronald W. Ward
Donald R. Marion	Fred J. Prochaska	Amar Siamwallah	Philip F. Warnken
Frank Martin	Wayne D. Purcell	Surjit S. Sidhu	Peter G. Warr
Larry J. Martin	Malcolm Purvis	Eugene Silberberg	Robert Weaver
Lee R. Martin	Allen P. Rahn	John Sjo	Steven B. Webb
Marshall Martin	Daryll Raitt	David Smallwood	Adolf Weber
Michael Martin	V. Ramachandran	Blair Smith	Finis Welch
Philip Martin	Allan Randall	Victor E. Smith	Delane Welsch
William E. Martin	Norman Rask	V. Kerry Smith	E. Boyd Wennergren
Robert Masson	Ronald A. Ratti	J. Herbert Snyder	Donald Alan West
Steve Matthews	Robert Raunikar	Mostafa Soliman	Randall E. Westgren
Scott C. Matulich	Philip M. Raup	Vernon Sorenson	Michael Wetzstein
Karl D. Meilke	Gordon Rausser	Stephen H. Sosnick	F. Weymar
William H. Meyers	Daryll E. Ray	Thomas H. Spreen	Ross S. Whaley
Jon R. Miller	Anthony J. Rayner	John D. Spriggs	Fred C. White
William L. Miller	Barbara Redman	B. F. Stanton	Maurice Wilkinson
Robert Milligan	Edward Reinsel	David C. Stapleton	Willard F. Williams
Marvin Miracle	Robert D. Reinsel	Robert Stern	Cleve E. Willis
John A. Miranowski	Gary C. Reisner	Robert D. Stevenson	John F. Wilson
Donald O. Mitchell	Shlomo Reutlinger	Tom Stinson	Don Winkelmann
Ronald C. Mittelhammer	Clark Reynolds	Herbert H. Stoevener	Michael Wohlgenant
Eric Monke	J. E. Reynolds	Ivar Strand	Abner Womack
Cynthia Taft Morris	James W. Richardson	Abraham Subotnik	Michael L. Wyzan
Timothy Mount	Harold M. Riley	Vasant Sukhatme	Pan A. Yotopoulos
Mohinder S. Mudahar	Kenneth Robinson	W. B. Sundquist	Douglas Young
Willard F. Mueller	Lindon Robison	Raymond J. Supalla	Robert A. Young
Wesley N. Musser	Terry Roe	Gene Swackhamer	Glenn A. Zepp
Walter P. Neely	Jacques Rolfo	Gurushri Swamy	Rod Ziemer
A. Gene Nelson	Sherwin Rosen	Earl Swanson	David Zilberman
Forest D. Nelson	Mark Rosenzweig	T. Takayama	Barbara Zoloth
Glenn L. Nelson	John Rosine	Hovav Talpaz	Paul S. Zukerman
Ken E. Nelson	Ahmad Rostamizadeh	Don C. Taylor	

Report of the Awards Committee

Special Award

John C. Redman, University of Kentucky.

Distinguished Extension Programs

Individual. **Richard L. Barrows,** University of Wisconsin.
Group. **Gerald A. Doeksen** and **James R. Nelson,** Oklahoma State University.

Distinguished Policy Contribution

Robert G. F. Spitze, University of Illinois.

Distinguished Undergraduate Teaching

Less than ten years' experience. **Kenneth L. Casavant,** Washington State University.
More than ten years' experience. **W. David Downey,** Purdue University.

Publication of Enduring Quality

Marion Clawson, *Methods of Measuring the Demand for and Value of Outdoor Recreation.* Washington, D.C.: Resources for the Future, 1959.

Outstanding Journal Article

William G. Tomek, "Price Behavior on a Declining Terminal Market." *Amer. J. Agr. Econ.* 62(1980):434–44.

Quality of Communication

Arley D. Waldo, Carole B. Yoho, Norbert A. Dorow, Thomas Ostenson, B. L. Flinchbaugh, and **Everett Peterson.** "Property Taxes—Reform, Relief, Repeal?" N. Cent. Reg. Extens. Pub. No. 39 and Minnesota Agr. Extens. Bull. 447, 1980.
Harold G. Halcrow. *Economics of Agriculture.* New York: McGraw-Hill Book Co., 1980.
Honorable Mention. Philip M. Raup. "Competition for Land and the Future of American Agriculture." *The Future of American Agriculture as a Strategic Resource,* ed. Sandra S. Batie and Robert G. Healy. Washington, D.C.: The Conservation Foundation, 1980.
Honorable Mention. Robert G. F. Spitze, Marshall A. Martin, Milton C. Hallberg, Tom A. Stucker, Alex F. McCalla, Bruce Gardner, Willard W. Cochrane, and **Sylvia Lane.** *Analysis of Food and Agricultural Policies for the Eighties,* ed. R. G. F. Spitze and M. A. Martin. North Cent. Reg. Res. Pub. No. 271 and Ill. Bull. 764, Nov. 1980.

Quality of Research Development

Oscar R. Burt, Won W. Koo, and **Norman J. Dudley.** "Optimal Stochastic Control of U.S. Wheat Stocks and Exports." *Amer. J. Agr. Econ.* 62(1980):172–87.
LeRoy Blakeslee. *Post World War II Government Policy Impacts on the U.S. Wheat Sector.* College of Agriculture Res. Cent. Tech. Bull. No. 93, Washington State University, 1980.
Honorable Mention. Richard E. Just and **Wen S. Chern.** "Tomatoes Technology and Oligopsony." *Bell J. Econ.* 11(1980):584–602.
Honorable Mention. Alan Randall and **John R. Stoll.** *Economic Surplus and Benefit-Cost Analysis.* Dep. Agr. Econ. AER Rep. No. 35, University of Kentucky, Oct. 1980.

Outstanding Ph.D. Thesis

Christopher Douglas Easter. "Supply Response with Stochastic Technology in Australia's Rural Export Industries." University of California-Davis (Quirino Paris, adviser).
Frederick Ian Johnson. "An Analysis of Brazil's Sugar Program, 1953–1975." University of Minnesota (Anne Krueger, adviser).
John Raymond Stoll. "The Valuation of Hunting and Related Amenities: A Conceptual and Empirical Approach." University of Kentucky (Alan Randall, adviser).

Honorable Mention (Ph.D. Thesis)

Saleh Halwan Humaidan. "Policies and Management Guidelines for Optimum Resource Utilization at Al-Hasa Irrigation and Drainage Project, Saudi Arabia." Oklahoma State University (Dean F. Schreiner, adviser).
Richard Mathew Klemme. "An Economic Analysis of the On-Farm Grain-Handling Decision Problem." Purdue University (David A. Bessler and Bruce A. McCarl, advisers).
Glenn Darwin Pederson. "A Conceptualization and Analysis of the Distributional Impacts of Alternative Agricultural Credit Policies." Michigan State University (John R. Brake, adviser).

Outstanding Master's Thesis

Richard Clay Barnett. "The Relationship between Domestic and International Liquidity and Nominal Agricultural Prices: A Time-Series Analysis." Purdue University (David A. Bessler and Robert L. Thompson, advisers).
Randall Ray Rucker. "The Dynamics of Montana Beef Cattle Inventories." Montana State University (Oscar R. Burt, adviser).
Ralph Semprevio. "Estimation of Economic Structural Parameters and Multipliers under Conditions of Multicollinearity in Simultaneous Systems." Virginia Polytechnic Institute and State University (Oral Capps, Jr., adviser).
Honorable Mention: Otto John Loewer. "The Economic Potential of On-Farm Biomass Gasification for Corn Drying." Michigan State University (Roy Black, adviser).

Honorable Mention: Abu Baker Bin Man. "An Econometric Analysis of the World Natural Rubber Market." Cornell University (David Blandford, adviser).

Honorable Mention: James Biklen Pendleton. "Allocation and Technical Efficiency of Traditional Agriculture in Northern Nigeria." Kansas State University (David W. Norman, adviser).

Honorable Mention: Robert M. Schoening. "Real Property Assessment Equalization and Preferential Assessment of Missouri's Agricultural Land: Effects on the Tax Incidence of Real Property Categories." University of Missouri (David Ervin, adviser).

Honorable Mention: Randolph Michael Sokal. "The Economic Effects of an Alternative to the Statutory Grain Freight Rates." University of Manitoba (E. W. Tyrchniewicz, adviser).

Honorable Mention: Yves Surry. "An Econometric Study of Future Trends in Demand for Soybeans and Soybean Products in France." University of Guelph (Karl Meilke, adviser).

Anne E. Peck, chairperson

Minutes

Minutes of the Executive Board Meeting, St. Louis, Missouri

The Executive Board acting as a program committee met in an informal session on 9 December 1980 at 8:00 p.m. to discuss the program for the 1981 meeting to be held at Clemson University.

The official meeting of the Executive Board was called to order by President Tweeten at 8:30 a.m. on 10 December 1980.

Present: Voting members:
Tweeten, Brown, Dennis, Heifner, Hopkin, Martin, Harl, King, Schuh

Members ex officio:
Koch Redman

Guests:
James (secretary-treasurer designate), Houck (editor designate), Pittman, Ikerd, Coats

1. Tweeten reviewed the agenda and obtained approval by general consensus.

2. Redman presented the minutes with corrections of the previously circulated copies of the 26–27 July 1980 meeting held at Urbana, Illinois. Brown moved the approval as corrected. Seconded. Passed.

3. Redman gave a preliminary report on the financial condition. The books will not be closed until 31 December, but reported that dues collection was down and payments on accounts due were slow. There appears to be a loss of about $1,650 on the annual meeting at Urbana. Hopkin moved that AAEA support the secretary-treasurer's assistant for one month and hopefully not more than two months for the purpose of closing the office smoothly at Kentucky. Seconded. Passed.

4. James, secretary-treasurer designate, reported that computerization of membership records was progressing nicely and that additional equipment was needed for the office. Hopkin moved that Iowa State University be authorized to purchase for AAEA suitable dictating and transcribing equipment. Seconded. Passed.

5. Hopkin reported for the Finance Committee. The portfolio subcommittee requested a reconfirmation of the authority by the Finance Committee to buy or sell equities up to 15% of the value of common stock in the portfolio without prior Executive Board approval. The Board clarified that the 15% limit was for the interval between Board meetings. Schuh suggested that the budgets for the past five years be prepared in "real terms" and that portfolio values be adjusted to reflect "real values" by using some acceptable index. No action was taken.

6. Schuh moved that the fidelity bond for the incoming secretary-treasurer be set at $100,000 and each secretarial assistant be at $10,000. Seconded. Passed.

7. Tweeten presented the report for Rhodes as outgoing editor.

8. Houck, as incoming editor, reviewed his plans and concerns and recommended that AAEA pay $200 as moving expenses for Martha Luzader. Hopkin moved that AAEA rèimburse Martha Luzader approximately $200 for moving expenses. Seconded. Passed.

9. Pittman reported on the activities being planned for the 1981 annual meeting at Clemson. Hopkin moved that the Clemson planning group be authorized to invite commercial concerns to have exhibits on a cost plus a fee schedule. Seconded. Passed. The secretary-treasurer is to provide mailing labels for mailing the meeting materials.

Hopkin moved that AAEA guarantee actual losses to Clemson University up to a limit equal to the difference between actual registration of members and 1,000 members times $30; and that Clemson and AAEA share in any surplus on a 50-50 basis. Seconded. Passed.

10. Ikerd presented comments on the role of the extension economist in the agricultural economics profession and in the AAEA. He expressed concern that extension economists do not have equal opportunity for publication in *AJAE* or as contributed papers at the annual meetings. The primary concern has been with research. The following proposals were specifically made:

(*a*) to include an economist with extension responsibility as one of the responders in all invited papers sessions at AAEA annual meetings;

(*b*) to identify selected papers sessions and organized symposia at the AAEA annual meetings with a rank order identification of potential interest with respect to research, extension, teaching, and industry members;

(*c*) to utilize the last half day of the AAEA annual meetings as meetings of the various segments within the association; research, teaching, extension, and industry;

(*d*) to require that the three top extension programs selected by the AAEA awards committee be shared with the other extension members of the AAEA;

(*e*) to include presentation of the top three extension programs in each category (group and individual) as a part of the AAEA annual meeting.

11. Hopkin moved that AAEA endorse in princi-

ple the cosponsorship of a symposium on "The Role of Professional Economists in Policy Work." Final approval will be subject to the endorsement of the AAEA Professional Activities Committee and the approval by a majority of the Executive Board when the program is developed. Seconded. Passed.

12. Coats reported on Federal Statistics Users Conference, indicating that AAEA would continue to support the FSUC and continue with the contacts already established.

13. The AAEA Membership Committee expressed interest in cross-checking names of members with the regional associations with the view of increasing membership of all associations.

14. Harl reported for the Resident Instruction Committee. He listed goals as follows: (*a*) obtain approval of a revised student section constitution and proposed revisions to AAEA Bylaws to implement changes; (*b*) revise the brochure "Economists in Agriculture, Business, Government, and Rural Affairs"; (*c*) develop an annual teaching workshop program; (*d*) promote student papers at the annual meetings; and (*e*) promote undergraduate student involvement in AAEA activities.

King reviewed the revised draft on the Student Section of AAEA Bylaws (Article XIII) and the proposed national constitution of the Student Section, American Agricultural Economics Association. Harl moved the approval of the revised section of the AAEA Bylaws (Article XIII) and the proposed constitution of the Student Section of AAEA. Seconded. Passed.

King moved that the proposal to revise the brochure be negotiated with Iowa State University as proposed. Seconded. Passed.

Harl led the discussion on developing a symposium or workshop on resident instruction and will convey to the committee the general sentiment of the Board to encourage the development of workshops.

There was a favorable reaction to the suggestion that the student chapters should receive the AAEA Newsletter as an encouragement of a greater involvement in AAEA activities.

Note: Because Redman had to leave early, James took the minutes that follow.

15. Dennis reported for the Industry Affairs Committee. He suggested a symposium around the subject "Embargoes Evaluated." It was decided that the industry group could handle the $100 honorarium needed for the banquet speaker at the annual meetings. This committee has a high priority goal of increasing the number of members. They request that the annual dues reminders go out earlier along with regular members.

16. It was moved by Schuh that the following committees be made standing: Extension, International, Industry, and Nominating. Seconded. Passed.

17. It was suggested that financial grants be sought now for the International Association of Agricultural Economists meeting in Jakarta, Indonesia, August-September 1982. It was moved by Schuh that the president appoint a committee on travel grants. Seconded. Passed.

18. James reported for the Handbook-Directory Committee. They recommend that the Association make maximum use of the Registry of Agricultural Economists (RAE) data base to produce the 1982 issue; that the new form being developed by Illinois State Employment Service (ISES) to collect RAE information be used in a joint effort, that the Board take action to encourage members to register for the RAE and the president prepare a letter to accompany the mailing to members; and that the *Handbook-Directory* contain name, address/telephone, rank or title, current employer, previous employer (three), nature of current employment activity, field of specialization, education, year of birth, citizenship, and current interest or research. It was moved, seconded, and passed that AAEA cooperate with RAE in the above outlined manner.

19. The work of the Publication of Postwar Literature Review Committee is winding down. Volume 3 will soon be off the press and volume 4 is in progress.

20. The Status of Blacks Committee is moving with deliberate speed. They are obtaining a membership list. There is a need to encourage more blacks into the profession, but a data base is needed first.

21. Tweeten discussed the Federation of Scientific Agricultural Societies (FSAS). The purpose of FSAS is to provide a forum for interdisciplinary communication and to enhance the capability of scientific agricultural societies to speak in a unified voice, re, national goals and priorities related to education and research; advise and counsel on public policy; assist colleges and universities in efforts to maintain and strengthen programs in research, teaching, and extension. King moved support and it was seconded and passed. King moved that Castle be asked to represent AAEA at the 17 February meeting. Seconded. Passed.

22. Considerable time was spent in developing the framework and identifying individuals for the invited papers section of the annual meeting. Also much discussion went into the consideration of and selection of nominees to forward to the Fellows Selection Committee.

23. Meeting adjourned.

Respectfully submitted,
John C. Redman, secretary-treasurer
Sydney James, secretary-treasurer (designate)

Minutes of the Executive Board Meeting, Clemson University

The meeting was called to order by President Tweeten at 8:30 a.m., 25 July 1981.

Present: Voting members:
Tweeten, Schuh, King, Brown, Hopkin, Dennis, Harl, Heifner, Martin

Members ex officio:
Ebert, Houck, James, Polopolus, Wyckoff, Havlicek

Guests:
Babb, Badger, Beattie, Bevins, Cordes, Eddleman, Evans, Faris, Fienup, Harris, Ikerd, Lewis, Peck, Robinson, Stanton, and various other committee members and reporting individuals

1. Harl moved the adoption of the agenda as prepared by Tweeten. Seconded. Passed.

2. Local arrangements for the following annual meeting were reviewed by Robinson and Faris. The goal of 1,000 registrants had been reached. There were no apparent problems. A dinner with the local staff, board members, and spouses was announced.

3. Tweeten reported the results of the election with Polopolus, president-elect, and Havlicek and Wyckoff replacing Brown and Hopkin as directors. The secretary-treasurer was granted permission to work with next year's Teller Committee in computerizing the counting of ballots.

4. The December 1980 minutes of the Board were presented and approved as amended by the following addition. It was moved by Schuh that the specific proposals made by the Extension Affairs Committee be detailed. Seconded. Passed.

5. James and Ebert reported on the status and condition of the business office. They reported that the move from Kentucky went smoothly with good cooperation. Space of one large room and one small office seems adequate and most refiling has been accomplished. Needed equipment has been purchased. The CPT word-processor is a much used item which simplifies office operations.

Much effort has been spent in computerizing membership and subscription name and address lists. This is now complete and a new program has been written which will incorporate *Handbook-Directory* information. Biographical data from the Employment Registry will be transferred early this fall. Additionally, the new program will contain personal information and data useful to the president and directors for management purposes.

A new liability insurance policy for the Association has been purchased and the office staff are all bonded. Dougherty & Company, certified public accountants, have been engaged to perform the annual audit. They will prepare the required federal tax forms.

The Western and Northeastern Associations were pleased with the joint dues billing for 1981. The Western Association increased their membership by about 200. Both wished to continue that service. Tweeten expressed the need for reciprocal arrangements. This met with Board approval.

The following motions followed the secretary-treasurer's report:

(*a*) Schuh moved "that a new class of membership be activated to be known as family membership for the spouse of a regular member and additional family members who are under the age of 18 and who are members of the family of the regular member. The dues per family membership shall be $12.50 per person per year. Individuals holding family membership shall not be entitled to receive, as part of membership in the Association, copies of the *Journal* or *Newsletter*." Seconded. Passed.

(*b*) Hopkin moved "that the maximum period of student membership be increased from 3 to 5 years." Seconded. Passed.

(*c*) Schuh moved "that beginning with 1982 dues, foreign memberships and subscriptions (outside of the U.S., Canada, and Mexico) be assessed $4 to cover additional mailing and handling fees instead of the current $2 charge." Seconded. Passed.

(*d*) Schuh moved "that the fee to back-order issues of the *Journal* be increased from $1 to $2 for those who pay dues later than January 15." Seconded. Passed.

6. Hopkin reported for the Finance Committee. The detail of budgets and receipts and expenses appear as a separate report. The 1981 budget and year-to-date accounting figures were reviewed. The 1982 budget was presented. After adjusting the 1982 budget for changes caused by Board action, it was approved by the Board. A $17,400 surplus is budgeted for 1981 following a $6,499 deficit in 1980. The projected deficit in 1982 is estimated to be $31,800. This is the approximate cost of printing the *Handbook-Directory*. It was moved by Hopkin, seconded and passed, "that there not be an increase in dues in 1982. This deficit would be covered from stock investments of the Association.

The Portfolio Subcommittee reported selling Browning-Ferris stock which had doubled its value in one year. Profits from this sale plus money-market investments were used to purchase four new stocks for a total of about $34,000. The total current value of the portfolio is near $511,400 consisting of $278,000 stocks, $94,600 bonds, and $138,000 money-market assets. Harl moved adoption of the revised 1981 budget. Seconded. Passed. Hopkin moved adoption of the 1982 budget. Seconded and passed after revision incorporating other Board action.

7. Hopkin reported that the Ad hoc Transfer Committee had finished its work with the move of the business office to Ames, Iowa, completed. There are some financial records and some funds still in Kentucky, but these will be transferred within a few weeks. The 1980 audit has been finished and the 1979 IRS tax audit will soon be completed.

Schuh moved "that the Transfer Committee be dissolved with a vote of thanks." Seconded. Passed.

Hopkin moved "that $100 be left in Kentucky for use by John Redman for postage and miscellaneous expenses." Seconded. Passed.

8. Houck reported on the condition and situation of the editorial office. The transfer from Missouri to Minnesota proceeded very smoothly. There was good cooperation by all. He was pleased with the four-up labels and computerization of names and addresses. Mailing has gone very well.

During the past 12 months 342 new manuscript submissions were received—a record number. In 1981 the *Journal* will publish 96 refereed articles, notes, and comments. At any one time there are 80–100 manuscripts out for review engaging 150–200 referees.

Bimonthly issues of the *Newsletter* will continue in 1982 under the current format. It is being printed by Bolger Printing Company of St. Paul, MN. There may be need in some future period to separate the *Newsletter* editor from the *Journal* editor. The functions and operations are such as to make this feasible. The *Newsletter* editor could do some things that the current editor does not have time for.

Havlicek will need to be replaced on the Editorial Board because of his recent election as director.

The difficulty of assigning page charges to proceedings issues was discussed. It was moved by Harl "that no charge be levied on the president's address, fellow's lecture, and invited addresses. All other papers presented would be assessed a page charge fee the same as for other issues of the *Journal*. Specific waivers can be granted by the editor with concurrence of the president. This policy applies equally to proceedings of the Allied Social Science Association." Seconded. Passed.

The large inventory of back issues of the *Journal* was discussed in detail. That inventory currently contains about 45,700 issues weighing about 18 tons and occupying 1,500 cubic feet of storage space. A graduated number was suggested for inventory control ranging from about 50 for older issues to 500 for more recent issues. Storage of these costs the Association about $1,000 per year. Harl moved "that the Association undertake during 1982 under the auspices and supervision of the secretary-treasurer of the Association, a campaign to provide an opportunity for individuals, firms, libraries, and others, to obtain copies of the *Journal*, published before 1980, at $2.50 per copy for North American purchasers and $3.00 per copy for other purchasers. The sale to be carried out on a first come, first served basis. Sales are to be discontinued whenever inventories fall below 75% of the levels suggested in the memorandum, "AJAE Inventory Policy dated 25 July 1981."

Considerable discussion centered around alternative forms for publishing the writings and work of Association members. A need was expressed in particular by the extension group but also included those in teaching and industry. Reference was to an earlier study of this matter appearing in vol. 60, no. 5 (Dec. 1978), pp. 1094–8, of the *Journal*. President Schuh will appoint another committee to again look at this matter. Concern was expressed by letter and in the Extension Committee report.

9. King by assignment presented a resolution supporting the establishment of a National Academy of Agricultural Sciences. King moved adoption and it was seconded and passed. The resolution will appear separately as part of the business meeting minutes. King presented a list of suggested changes which clarified the language of the proposed document to reflect and clarify economic issues and terms. The latter was to be presented to the writing team for their consideration.

10. Miscellaneous correspondence requiring Board attention was presented.

(*a*) The consensus was that the review process for material appearing in the Proceedings issue of the *Journal* need not be changed.

(*b*) Long survey questionnaires were an apparent difficulty for some. It was agreed that the secretary-treasurer should exercise discretion in providing mailing labels including a review of the questionnaire which could go to the president if further consideration were necessary.

11. Stanton reported for the Agricultural Economics Financial Resources Committee. Funding of agricultural economics research was thought to be one of the more serious matters. Uncertainty was expressed over ESS (ERS). Interference with the freedom of research was a concern. Some statistical series are being cut. It was agreed that this committee should continue and they should consider the possibilities for conducting a workshop including ESS, industry and academia to consider this matter in detail.

The CRIS system was discussed. It was felt that there were problems with the output not reflecting actually what was being done by economists.

12. Ikerd reported for Extension Affairs Committee. It was moved by Harl "that Affairs be removed from this title as well as for the Industry Affairs Committee." It was seconded and passed.

Appreciation was expressed for the invited papers session specifically to deal with extension delivery systems. Disappointment was expressed that the Board had not dealt with his proposals made at the December meeting.

Additional proposals dealt mainly with publication outlets for extension economists

(*a*) to change the editorial system of the *Journal* to include associate editors in research, extension, and teaching.

(*b*) to give serious consideration to dividing the "Notes" section of the *Journal* into separate Extension, Teaching, Research, and Industry parts.

Ikerd did not recommend a popular version of the *Journal* for the fear of ranking.

The Board deferred action on these and former proposals of this committee until more time could be devoted to their consideration. It was agreed that a new and separate committee should be ap-

pointed to study the publications of the Association as mentioned in item 8.

13. The report of the Membership Committee was accepted with appreciation. It was noted by James that memberships for 1981 was now about 200 above last December and should increase to about 300. Campus recruiters will be provided membership lists earlier in 1982 than in 1981.

14. Cordes reported for the Professional Activities Committee (PAC). Recommendations generated the following Board actions:

(*a*) Moved by Harl to cosponsor a Farm Foundation conference titled "Perspectives on Agricultural Food Policy Research." Seconded. Passed.

(*b*) Moved by Hopkin to cosponsor a USDA conference titled "The Economics of Food and Agricultural Trade," but not the publication of the proceedings in the *Journal*. Seconded. Passed.

(*c*) Moved by Dennis to cosponsor two conferences proposed by the American Society of Agricultural Engineers: "Second International Livestock Environment Symposium" and "International Conference on Plant and Vegetable Oils." Seconded. Passed.

(*d*) Moved by King not to give an award for "Excellence of Published Research in Economic Development." Seconded. Passed.

In addition seven issues were placed before the Board. These issues and actions follow:

(*a*) That the Association develop a policy of conduct for its officers while holding office. King moved the adoption of PAC's statement as follows:

> "It is the personal obligation and responsibility of individual board members, committee members, and officers to (1) avoid the misuse of the Association for the personal gain of oneself or others or (2) avoid involvement in decision-making activities that represent a conflict of interest with regard to AAEA. In situations of doubt, the individual is to apprise the Board of the situation, and ask for its counsel."

Seconded. Passed.

(*b*) That the Association look into additional services which could be provided its members. PAC was charged to retain this area of concern.

Written job descriptions for standing committees will be referred to President-elect Schuh for handling as he sees fit.

(*c*) Increasing the privileges associated with Association membership was thought to belong to PAC. Acceptance of Issue 3 without action was moved by Hopkin. Seconded. Passed.

(*d*) No official action was taken on Issue 4 relating to annual meeting content. In the December 1980 *Newsletter*, President Tweeten spelled out the procedure now in use for developing the program for annual meetings.

(*e*) The role of the 1890 Institutions was deferred until the Committee on Blacks reported.

(*f*) The policy analysis capabilities of the profession (Issue 6) was deferred to Stanton's committee on current policy issues.

(*g*) The need for AAEA policy guidelines was expressed. This involves the missions of the various committees. No Board action was taken, but Tweeten expressed willingness to survey those committees he appointed as a beginning for such a compilation.

15. Harris reported for the Resident Instruction Committee. The corrected Constitution for the SS-AAEA was distributed including Section XIII of the Bylaws. Harris presented a new career brochure and Harl moved its acceptance. King moved "that Agricultural Production, Marketing, Credit, Natural Resource and Rural Development be added under the main heading." Seconded. Passed. Wyckoff moved to add the word management. Seconded. Passed. Schuh moved "to include Policy." Seconded. Passed on a 4 to 3 vote. The original motion passed. The secretary-treasurer will advertise the new brochure and sell on a cost basis.

The committee expressed appreciation for the symposium "Dimensions in Teaching Agribusiness Management, Farm Management, and Agricultural Policy." Future plans call for a two- or three-day workshop in 1983.

16. The report of the Industry Affairs Committee was accepted with no Board action. A membership of 43 was noted The current method of invoicing was appreciated. They were pleased to have been given an opportunity to organize a symposium at the annual meeting entitled, "Embargoes Evaluated."

17. Fienup reported for the International Committee. It was noted that in separate action under the recommendation of Wyckoff, the Board had approved $7,500 in travel grants to the IAAE meetings in Indonesia in 1982. Requirements for obtaining a grant are (*a*) member of AAEA, (*b*) U.S. citizen, (*c*) under 36 years old, and (*d*) have an international dimension in their work.

The committee has used its time promoting seminars and workshops. The ADC/RTN workshop planned was not held because of a lack of funding. However, the International Committee did jointly sponsor a RTN seminar on "Food System Organization Problems in Developing Countries." They were pleased to have a place in the annual meetings. Report accepted.

18. The report of the Postwar Literature Review Committee was accepted. Babb noted that for volumes 1 and 2, $7,741 of royalties has been paid for 3,216 copies sold. To date, 319 copies of volume 3 have been sold.

19. The report of the Literature Retrieval Committee was given by Badger. The Board was encouraged to support the AAEDC at a level of $21,000 for next year (1 Oct. 1981 to 30 Sep. 1982). This support was moved by Schuh. Seconded. Passed.

Mention was made that University of Missouri has a complete cross-referenced *AJAE* file. This file is available through the Department of Agricultural Economics.

This committee offers its services to area associations and individual departments in conducting workshops demonstrating what is available and how to retrieve the information. Commercial vendors are willing participants of such workshops.

Plans are to publish a quarterly newsletter highlighting new agricultural economics and related files.

20. James reported the current status of the next *Handbook-Directory.* Approximately 2,200 Employment Registry forms have been returned, leaving a shortage of near 1,800 members. This information will be transferred by tape to Iowa State University to be read into the new computer membership file. A second survey of the membership using a simplified form was authorized with a deadline of 15 December for completion. The plan is for the biographical data collected to appear on the membership dues invoice for correction and update. Harl moved "that the letter "O" be used instead of "W" for the telephone code." Seconded. Passed.

Further, it was moved by Harl "that the Executive Board approve publication of a *Handbook-Directory* to include the information contained in the sample sheet distributed to the Board for examination and reaction and that the Handbook-Directory Committee review the sections of information included in the *Handbook-Directory* with encouragement to eliminate (*a*) those sections containing information published elsewhere, (*b*) those sections with low rates of perceived usage, and (*c*) those sections the inclusion of which will result in undue delay of publication of the *Handbook-Directory.*" Seconded. Passed.

21. The report of Professional Registries and Employment Committee was received but no action was taken. Johnson was pleased that there were about 1,645 agricultural economists listed in the Employment Registry who express interest in being considered for some type of employment. Illinois Job Service is satisfied with the performance and plans to continue the service. The committee will develop a new flyer explaining the services and purposes of the Professional Registry.

22. Lundeen reviewed the results from the survey conducted by the Status of Women Committee. Hopkin moved to recommend "that the Committee become a special Committee." Seconded. Passed.

23. Evans reported for the Status of Blacks Committee. He reviewed a questionnaire they were planning to use to study blacks in the profession. The proposal is now ready for funding. Several sources were suggested. Tweeten asked that he keep in mind the 1890 institutions in his study.

Harl moved "that the Board endorse the study of black and nonblack agricultural economists." Seconded. Passed.

The secretary-treasurer is to cooperate in furnishing name lists.

24. Lewis, acting head of the Department of Economics, Utah State University, reported plans for next year's meetings. This will be cosponsored by the Western Association. Beattie, president, expressed interest in jointly selecting the contributed papers and having a special session for the Western Association. They will publish their own proceedings.

Facilities were reported to be adequate to house the 1982 meetings.

Bevins, president of the Northeastern Association, requested that the 1984 meetings be held jointly at Cornell University. It was so moved by Schuh. Seconded. Passed.

25. Peck reported for the Awards Committee. This year's winners were presented. She was thanked for the excellent work she had done. Because of possible confusion over one person being selected to receive two similar awards, the following motion was moved by Harl, "If an article is selected to receive both the Outstanding *Journal* Article Award and Quality of Research Discovery or Quality of Communication Awards, the matter shall be resolved by the chair of the Awards Committee in consultation with the recipient or recipients involved." Seconded. Passed.

26. Schuh moved the following nominating committee for 1982 elections: Kenneth C. Clayton, Gerald L. Cole, George Lee, Alfred L. Parks, Joseph C. Purcell, J. William Uhrig, and Russell Yeomans. Seconded. Passed.

27. The next Board meeting was scheduled for 20, 21 November in St. Louis. There will also be a meeting 28 December in connection with the ASSA meetings in Washington, D.C.

28. In accordance with the Bylaws, the secretary-treasurer and editor were evaluated by the executive board with reappointment for next year.

29. Those board actions making changes in the Bylaws were reviewed by Harl with specific wording presented. These were moved, seconded, and passed.

Respectfully submitted,
Sydney C. James
Secretary-Treasurer

Minutes of the Annual Business Meeting, Clemson, South Carolina

The 70th annual business meeting was called to order by President Luther Tweeten on 28 July 1981 at 8:30 a.m.

1. Tweeten presented for approval the minutes of the previous annual business meeting held at Urbana, Illinois, 29 July 1980, as published in the Proceedings issue, of the *Journal,* December 1980, p. 1146. Seconded. Passed.

2. The results of the recent elections was announced with Leo Polopolus, president-elect, J.B. Wyckoff and Joseph Havlicek, Jr., directors. Each

of the Board members was individually recognized. Retiring Board members were thanked for the service they had rendered.

3. Tweeten reviewed items of interest and importance to the general membership from the past two meetings of the Board. The following items are detailed in the Board minutes: the need for additional biographical data to publish a good *Handbook-Directory*, family memberships, increasing the longevity of student memberships to five years, increased costs of postage and handling for foreign memberships to $4, increased cost for obtaining late membership back issues of the *Journal* to $2, selling of overinventoried issues of the *Journal* at mailing costs, the increase in membership since last December, the creation of a new careers brochure, travel grant to the IAAE meetings, support of AAEDC, and special thanks to all those who had worked so hard and willingly on committees and various assignments over the past year.

4. James reviewed the status of the Association business office. The move from Kentucky was made with full cooperation. The office is now operating smoothly with refiling nearly completed. Membership vouchers should go out on time this year. Computerization of membership records and *Handbook-Directory* information was reviewed. The business office is established to serve the membership.

5. Redman presented the 1980 financial report, which appears separately. He called attention to the fact that the operating statement was on a cash basis and year-end summaries would be expected to show some variations. The transfer of offices disrupted some operations and resulted in some additional expenses.

6. Hopkin distributed and discussed the annual budgets. He reported that the Association was financially healthy. He called attention to increasing editorial costs and to the transfer costs of both the secretary-treasurer's office and the editor's office. The balance of the financial accounts will be transferred from Kentucky to Iowa shortly. Budget data appear separately.

7. Tweeten read the auditor's report indicating that all financial accounts are in proper order.

8. Houck reported the condition of the editor's office. He reviewed the review process and magnitude of the operation.

9. Tweeten recommended the previous action of the Board to change the Extension Affairs Committee, Industry Affairs Committee, International Committee, and Nominating Committee from special committees to standing committees and to drop the word "Affairs" from the Extension and Industry Committees. It was moved, seconded, and passed.

10. The resolution prepared by King in support of the establishment of a National Academy of Agricultural Sciences was presented. It was moved, seconded, and passed. The text of this resolution appears separately.

11. A resolution of appreciation to Clemson University for hosting the 1981 annual meetings was presented by President-elect Polopolus. It was moved, seconded, and passed. The text of the resolution appears separately.

12. The schedule of upcoming meetings was reviewed:

Annual summer meetings;

1982	Utah State University, Logan, Utah
1983	Purdue University, West Lafayette, Indiana
1984	Cornell University, Ithaca, New York
1985	Iowa State University, Ames, Iowa
1986	Open

Allied Social Science Association, all scheduled to be held 28–30 December in their respective years:

1981	Washington, D.C.
1982	New York, New York
1983	San Francisco, California
1984	Dallas, Texas
1985	New York, New York

13. The new nominating committee was presented by incoming President Schuh. (Names appear in the minutes of the Board.) They were moved, seconded, and passed.

14. The presidency was conveyed from Tweeten to Schuh and he adjourned the meeting.

Respectfully submitted,
Sydney C. James
Secretary-Treasurer

Resolutions

In support of the establishment of a National Academy of Agricultural Sciences,

Whereas the National Academy of Sciences is "dedicated to the furtherance of science and its use in the general welfare," and

Whereas agriculture, engineering, and medicine constitute the three primary fields of applied science, and

Whereas a National Academy of Engineering and an Institute of Medicine are now established under the charter of the National Academy of Sciences, and

Whereas there is need for a recognized multidisciplinary body of competent and creditable scientists and scholars who may provide advice and counsel on national policies, issues, and programs to enhance the achievement of national and world agricultural goals,

Be it therefore resolved that The American Agricultural Economics Association (AAEA) hereby recommends that the United States establish a National Academy of Agricultural Sciences under the charter of the National Academy of Sciences to complement and assist the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine in furthering science and the general welfare, in serving as advisor to

federal government, and in guiding the National Research Council. More specifically, the National Academy of Agricultural Sciences shall have as its purposes:

(*a*) to advise the federal government on agricultural production, distribution, and stewardship for future generations of the nation's agricultural and natural resources;

(*b*) to assess needs, identify priorities, and project goals for agricultural research and education;

(*c*) to foster interdisciplinary study and cooperation within the science community on national and global agricultural issues;

(*d*) to recognize scientists and scholars for outstanding contributions to the generation, integration, and application of knowledge in agriculture.

Further, that the Secretary of AAEA be directed to send copies of this resolution to the President of the National Academy of Sciences and the National Research Council and to representatives of organizations presently affiliated with the Federation of Scientific Agricultural Societies.

Adopted by the AAEA Executive Board on (25 July 1981) and approved by the membership of AAEA at its annual business meeting at Clemson University this 28th day of July, 1981.

Resolution

The officers, members, families, and guests of the American Agricultural Economics Association acknowledge the warm and cordial hospitality exhibited by the faculty and staff of Clemson University on the occasion of the annual meeting held on the Clemson University campus, 26–29 July 1981. Therefore,

Be it resolved that the American Agricultural Economics Association express its sincere gratitude to Dr. Bill Atchley, president of Clemson University, Dr. Ed Faris, head of the Department of Agricultural Economics and Rural Sociology, and Dr. Bob Robinson, chairman of the Steering Committee, Dr. Jerold Pittman, as well as the faculty, staff, students, and families of the Department of Agricultural Economics and Rural Sociology of Clemson University.

Be it further resolved that a copy of this Resolution be sent to President Atchley, Dr. Ed Faris, and Dr. Bob Robinson, plus copies to each member of the Steering Committee and others at Clemson University as deemed appropriate.

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Subjects

Agricultural Products; Demand, Supply, Prices; Food, Consumer, and Household Economics

Economic Growth and Development; Planning Models; Fluctuations; Technological Change; Aggregate Production Capacity; Regional and Community; Migration

International Economics; Trade; Integration; Business Aid

Marketing; Agribusiness; Cooperatives; Transportation; Industrial Organization; Vertical Coordination

Natural Resources; Energy; Conservation; Environment; Wastes; Land Use and Tenure; Recreation; Water; Fisheries

Production Economics and Management; Risk and Uncertainty

Public Issues and Policy; Agricultural; Regulations; Taxation; Inflation; Welfare Programs; Poverty; Regional and Community Development; Education; Health

Research Methodology; Modeling; Techniques; Agricultural Data

Authors

Editors of the *Journal of Farm Economics* (vols. 1–49) and

***American Journal of Agricultural Economics* (vols. 50–63)**

L. A. Moorhouse	Office of Farm Management, USDA	Vols. 1–3	1919–21
O. C. Stine	Bureau of Agricultural Economics, USDA	4–6	1922–24
E. G. Nourse	Institute of Economics Brookings Institution	7–8	1925–26
H. R. Tolley	Bureau of Agricultural Economics, USDA	9–11	1927–29
H. E. Erdman	University of California-Berkeley	12–14	1930–32
O. B. Jesness	University of Minnesota	15–17	1933–35
H. C. M. Case	University of Illinois	18–19	1936–37
T. W. Schultz	Iowa State University	20–23	1938–41
H. B. Price	University of Kentucky	24–25	1942–43
Warren C. Waite	University of Minnesota	26–30	1944–48
Walter W. Wilcox	Library of Congress	31–33	1949–51
Lawrence W. Witt	Michigan State University	34–36	1952–54
Harold G. Halcrow	University of Connecticut	37–39	1955–57
Robert L. Clodius	University of Wisconsin	40–41	1958–59
Herman M. Southworth	Pennsylvania State University	42–44	1960–62
James Nielson	Michigan State University	45–47	1963–65
Earl R. Swanson	University of Illinois	48–50	1966–68
Varden Fuller	University of California Berkeley (1969) Davis (1970–71)	51–53	1969–71
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Max R. Langham and Leo Polopolus, coeditors	University of Florida	55–56	1973–74
William G. Tomek	Cornell University	57–59	1975–77
V. James Rhodes	University of Missouri	60–62	1978–80
James P. Houck	University of Minnesota	63–65	1981–83

Objective

The AAEA seeks to further the systematic development of knowledge of agricultural economics in order to improve agriculture and agriculture's contribution to the general economy. The activities of the AAEA include:

—publishing the *American Journal of Agricultural Economics;*
—planning and conducting two annual meetings of the membership;
—sponsoring annual awards for outstanding extension programs, distinguished teaching, and outstanding research;
—recognizing outstanding agricultural economists through a fellows program;
—supporting a literature retrieval system in cooperation with the U.S. Department of Agriculture;
—publishing periodically a biographical directory of the AAEA's members;
—supporting an employment registry for agricultural economists in cooperation with the U.S. Department of Labor.

Membership and Subscriptions

Membership in the AAEA is open to individuals having a professional interest in agricultural economics. Dues, payable at the beginning of each calendar year, are as follows: regular members, $25, senior members, $12.50, and junior members, $12.50. Senior membership is open to persons, upon written request, who are sixty-five years of age or older and have retired from active professional work. Junior membership is for students and is limited to three years; students should use application forms available from and signed by the head of the department in which they are studying. Members receive this *Journal*

Any firm, corporation, association, or partnership may become an institutional member upon payment of $100 per year; institutional members receive three copies of each issue of the *Journal*. Library subscriptions are $35 per year. Individual issues of this *Journal* are $10.00.

Payment of membership dues, correspondence regarding subscriptions, orders for individual copies of the *Journal*, changes in address, or inquiries about the general affairs of the AAEA should be sent to Sydney C. James, Secretary-Treasurer, American Agricultural Economics Association, Department of Economics, Iowa State University, Ames, Iowa 50011.